

Bk. 4

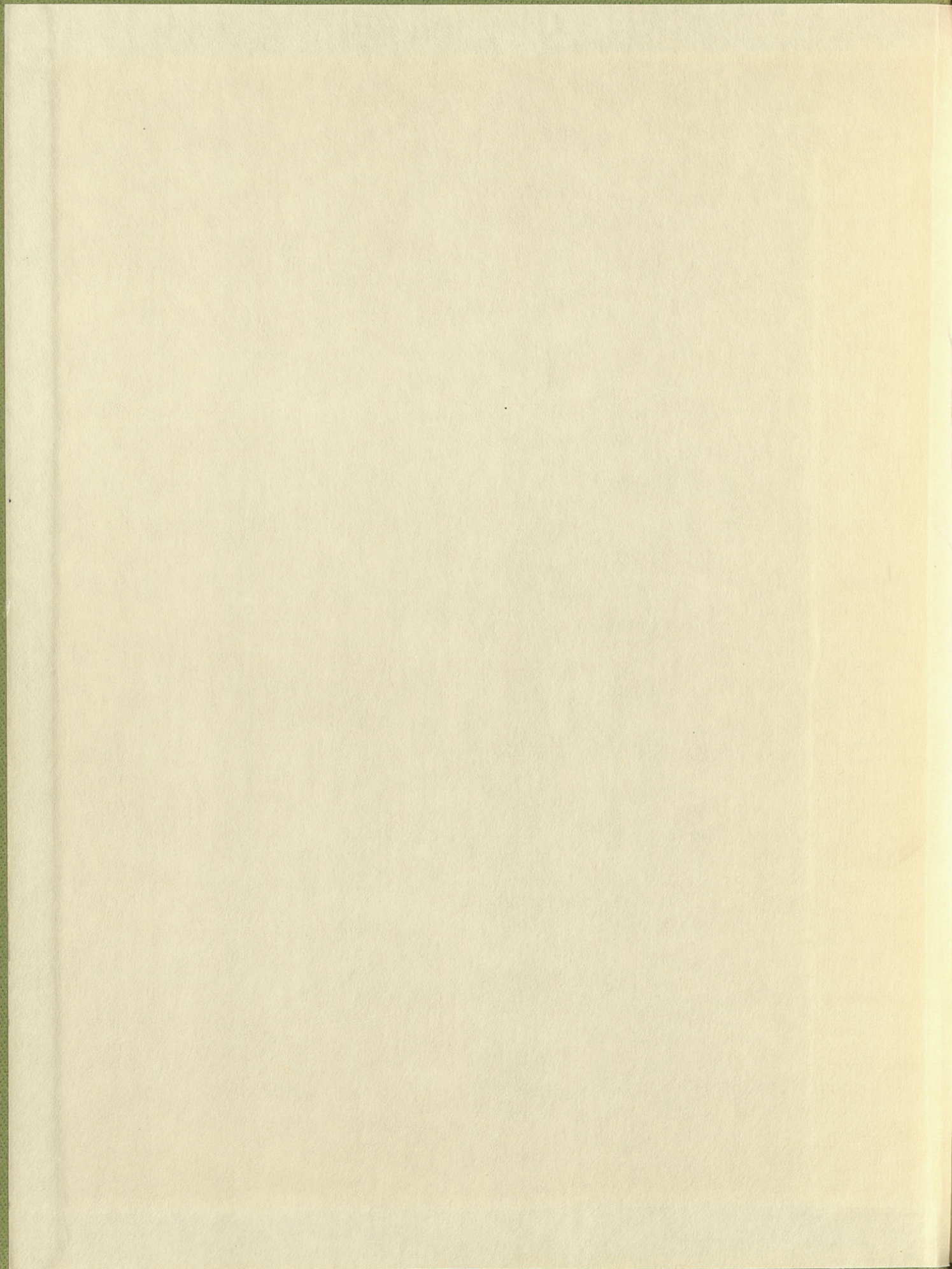
W. RALL

4

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Washed K.C.

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Mostly 1964 Research Diary

6/19/63

The purpose of this record is to collect notes & outlines presently on loose sheets of paper, with a view to a more efficient dispatch of unfinished papers based on accumulated computations. Basic problems ~~is~~ seems due to two principal factors:

(1) evolving research interests

(2) priority given to invited papers.

Solution would seem to lie in brief papers instead of buried notes.

(This comment follows not long after completing Ojai manuscript)

6/19/63

Research Diary

Monday 11/11

The purpose of this record is to collect
 notes & outline present of on loose
 sheets of paper, with a view to a
 more efficient disposal of unpublished
 papers based on accumulated

computations. Basic problems seem
 due to two principal factors:

(1) evolving research interests

(2) priority given to invited papers.

Solution would seem to lie in brief papers
 instead of invited lectures.

(The amount follows not last of computing (see manuscript))

Here is copy of list prepared 2/13/62 just before Wash. Biophys. Soc. Meeting

- ① Complete basic potential distribution paper
 - Ⓐ This involves completion of figures
 - Ⓑ new introduction
- ② Membrane potential to be dealt with in a separate paper.
This could include: Sum of series approach and a brief recap of V_e and V_i of 1953 abstract (relation of $V_e + V_i$ to R_e and R_i).
Also integral for case of linear fan of r_e for extracellular source weights.
Also discuss isopotentiality of soma membrane.
- ③ Paper with Ezra & Jeanne
- ④ Spherical Symmetry case in Stockholm: expanded
- ⑤ Computations for pyramidal cells
- ⑥ Computations for generator potential with $\rho \neq \infty$
- ⑦ also for finite dendritic length.
- ⑧ Computations for synaptic E & I for $\rho \neq \infty$
- ⑨ Current step to soma for finite dendritic length & $\rho \neq \infty$
- ⑩ Paper with Aitken, or at least theory
- ⑪ Dendritic E & I transfer functions (? approx)
- ⑫ ? Fuortes model. — Nelson, Terzuolo — Voltage Clamp Model.

1
This is copy of list prepared 2/13/62 just before bookkeeping Soc Meeting

1) English basic potential distribution paper
2) This was our completion of figures
3) new introduction

4) Papers are identical to be best with in a separate paper.
This will include: sum of series approach and a draft recap
of the work of M.E. Sargent (letter of 10/10/61 to R. K. L.)
This material for each of these found in his experimental source weights
also shows a potential distribution of source measurements.

5) Paper with 2 x 2 frame
6) Physical experiment (see in stockholder's separated

7) Calculations for potential cells
8) Calculations for potential with $\mu = \infty$
9) Data for finite arithmetic length

10) Calculations for separate 2 x 2 for $\mu = \infty$
11) Current step to source for finite arithmetic length $\mu = \infty$

12) Paper with column or at least theory
13) Distributor 2 x 2 transfer functions (approx)
14) Factor matrix. - When transfer matrix completed

3/11/64

2

New to continue as Research Diary
This will be Bk. 4 to continue from Bk 3, just filled.

BK. 1 is so far incomplete record of 1959-1962 computations
Being reconstructed from loose notes of work with
Ezra, Jeanne, Witmer, Brunelle & early H-800

BK. 2 record of Compartmental Computations with
Berman-Weiss program 7/62 - 63
Includes calcs for Ojai & also degeneracies &
early exploration of non-linear systems.

BK. 3 record focussed on Propagation Computations
11/63 - 3/64 but gradually transformed into
a running research diary with numbered pages.

3/11/64

How to continue as Research Director
This will be B.K. 1 to continue from B.K. 3, first filled.

B.K. 1 is a paper in complete record of 1959-1962. Computations
being reconstructed from loose notes of work with
Singer, James, Weston, Bromwell & early H-800

B.K. 2 is record of experimental computations with
Bromwell, West's program 7/62-63
includes also for CIP, West's program &
early application of non-linear systems.

B.K. 3 record focused on experimental computations
11/63-3/64 but probably transformed into
a summary research diary with numerical papers.

3/11/64

3

The list of unfinished papers has grown during the past two years (i.e. since the list of p.1 was prepared)

Item (8) and part of item (11) were taken care of in the Ojai manuscript prepared a year ago & recently read in page proof.

With Gordon Shepherd, the Aitken material is being pushed into publishable form. Also, new theoretical result on pp 83-88 of Bk 3, on averaging equally probable depths.

However have much new material to be worked up for publication: (see pp 89 of Bk 3, or p.5 below)

exp. Theory for V_e in cortical layer
Application to Olfactory Bulb
Model for propagation, & its analysis
(see pp 91 & 93 of Bk 3)

Also miniature epsps
Impedance effects of remote synaptic activity.
(Pestley in relation to Tom Smith)
Extracellular potentials of motoneuron populations p. 92
(as brought up again by Van Buren) in Bk. 3

Also in progress is tree generation with Farrow & Graber
Bk 3 pp 65, 75,

Note that Aitken's letter of 1st March 1960
estimated order of 20% shrinkage, overall
for the large blocks used.

$$(0.80)^{3/2} = 0.735$$

$$(1.25)^{3/2} = 1.4$$

true dendritic conductance would be 1.4 times that
calculated without a correction for shrinkage.

3/12/64

Re Intro. of Dendritic Branching

4

Note that former WXR603C with WXR67C was recently revised & recompiled as WXR604C with WXR68C. Compiled without trouble, but system could not load (system error).

Finally overcome 3/9/64-3/10/64.

This new version provides for TRFAC = factor correcting for trenches not seen.

Also, computes ratio of extrop. surface area to seen surface area.

Also, prints out the rescaled electrotonic lengths each time

Also computes { RNBAX, RNTWAX, RNINF
& prints { GNBAX, BNTWAX, GNINF

Wrote Aitken on 3/5/64 to inquire specifically about perikaryon depths; whether cutting perikarya can or cannot be ruled out, and about section thickness for bitten cells.

Using
$$\bar{f} = \frac{\sqrt{h^2 + 2h|x| + b^2} - b}{h + 2|x|} \quad \text{from p. 87 of Bk. 3}$$

Consider two cases for bitten cells

$$h=100, \text{ with } b=25, |x|=10$$

$$\begin{aligned} \bar{f} &= \frac{\sqrt{126.25} - 2.5}{10 + 2} \\ &= (11.25 - 2.5) / 12 \\ &= 8.75 / 12 = 0.729 \\ &= 1 / (1.38) \end{aligned}$$

$$h=200, \text{ with } b=25, |x|=10$$

$$\begin{aligned} &\frac{\sqrt{446.25} - 2.5}{20 + 2} \\ &= (21.12 - 2.5) / 22 \\ &= 18.62 / 22 = 0.846 \\ &= 1 / (1.18) \end{aligned}$$

for $|x|=0$

$$\sqrt{106.25} \text{ etc}$$

$$\begin{aligned} \rightarrow (10.3 - 2.5) / 10 &= 0.78 \\ &= 1 / (1.28) \end{aligned}$$

for $|x|=0$

$$\sqrt{406.25} \text{ etc}$$

$$\begin{aligned} \rightarrow (20.15 - 2.5) / 20 &= 0.8825 \\ &= 1 / (1.135) \end{aligned}$$

People to write or talk to:

Tom Smith

FitzHugh

Aitken

Braitenberg

Kathryn Thomas (Minnesota)

Jim Fu Tang

$$\begin{aligned}
 & \lambda = 200, \text{ with } \lambda = 22, \kappa = 10 \\
 & \frac{110000 - 22}{10 + 0} \\
 & = (20.12 - 22) / 22 \\
 & = 18.0 / 22 = 0.818 \\
 & = 1 / (1.18)
 \end{aligned}$$

$$\begin{aligned}
 & \text{for } \kappa = 0 \\
 & \rightarrow (20.12 - 22) / 20 \\
 & = 0.88 = 1 / (1.132)
 \end{aligned}$$

$$\begin{aligned}
 & \lambda = 100, \text{ with } \lambda = 22, \kappa = 10 \\
 & \frac{110000 - 22}{10 + 0} \\
 & = (11.22 - 22) / 12 \\
 & = 8.72 / 12 = 0.727 \\
 & = 1 / (1.37)
 \end{aligned}$$

$$\begin{aligned}
 & \text{for } \kappa = 0 \\
 & \rightarrow (10.3 - 22) / 10 = 0.78 \\
 & = 1 / (1.28)
 \end{aligned}$$

3/12/64

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Papers to be completed (list from p. 89 of Bk 3 dated 3/4/64)

Copy note for Eccles Commemorative Volume 8/11/64

Dendritic Synaptic Patterns: Experiments with a Mathematical Model

Paper on Branching Extrapolation for Dendritic Radial Symmetry

" " Dendritic Surface Area Estimates from Author's Data

" " Dendritic Input Conductance " " " " " "

" " Analysis of Sholl's data

Theoretical Dists of V_e & V_i for spherical soma

" " " V_m " " " "

" " of V_e for asymmetric dendrite (Egza & Jeanne)

" " transients for radially sym (Stockholm 10 min paper)
& relation of V_i , $2V_i/\rho x$, I_m , V_e , etc.

Theory for V_e with synch. act. in cortical layer

Comparison of Theory & Expt. for antidrom. in Olfact. Bulb

Math. Model. for Comput. of Action Potential Propagation
into Regions of Changing Geometry & Safety Factor

(maybe break in two?)

Calc. of miniature eppsp generated at different locations (Katz)

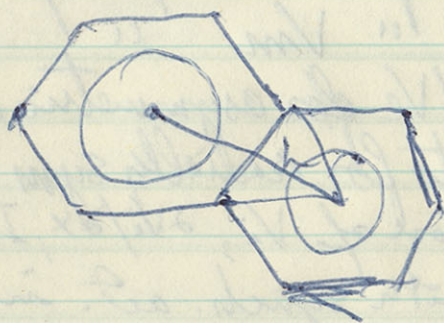
of locations & degeneracies & effect of β value.

? Hypothesis on synaptic plaques

? Hypothesis on core conductance changes

Diagrammatic & descriptive of single cell, populations,
layers, synch. activity.

As of today. Need to prepare annual report.



$$\triangle \quad h = \frac{1}{2}b$$

area of equilat. \triangle is $\frac{1}{2}bh$

$$\text{where } h = \sqrt{b^2 - \frac{1}{4}b^2} = \frac{\sqrt{3}}{2}b$$

$$\text{or } \frac{1}{2}b = \frac{1}{\sqrt{3}}h$$

$$\therefore \text{area of } \triangle = \frac{h^2}{\sqrt{3}}$$

$$\text{and area of hexagon} = \frac{6h^2}{\sqrt{3}} = \frac{6h^2}{4\sqrt{3}}$$

3/18/64

6

Calculation to relate synaptic contact area as proportion of total area, to contact ratio in profile.

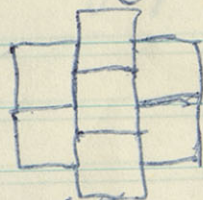
Need to assume some sort of model. Suppose ^{at first} the contact areas are circular and their centers are arranged according to a hexagonal lattice over the dendritic surface. If d is the diameter of each circle and L is the distance between centers, one would expect the average profile ratio of contact to total to be d/L , while the ratio of contact area to total area would be

$$\frac{\text{area of circle}}{\text{area of hexagon}} = \frac{\pi d^2/4}{6L^2/(4\sqrt{3})} = \frac{\pi\sqrt{3}}{6} \left(\frac{d}{L}\right)^2 = 0.907 \left(\frac{d}{L}\right)^2$$

\therefore if $\frac{d}{L} = 1$, get 0.907 for inscribed circle in hexagon

If contact area is also hexagonal, get $(1) \left(\frac{d}{L}\right)^2$

In general, for other lattice, such as



if contact area is assumed to have same shape as the lattice element, get $\left(\frac{d}{L}\right)^2$

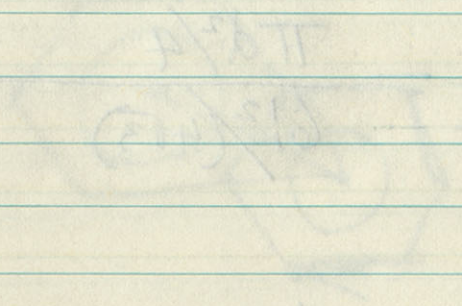
if shape is different, get some factor less than unity $\times \left(\frac{d}{L}\right)^2$

All this relevant to Kathryn Thomas's % membrane area covered by synaptic endings.

Calculator to relate sample control area to
 proportion of total area, the control value in pixels.
 Need to determine some sort of model. Suppose the
 control area are circular and their centers are
 arranged according to a hexagonal lattice over the
 sample surface. If d is the diameter of each circle
 and L is the distance between centers, one would
 expect the average pixel ratio of control to total
 to be d^2/L^2 , while the ratio of control area
 to total area would be

$$\frac{\pi d^2/4}{L^2} = \frac{\pi d^2}{4L^2}$$

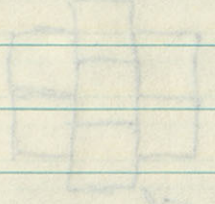
$$= 0.785 \left(\frac{d}{L}\right)^2$$



area of circle
 area of hexagon

is of $L = 1$, set $d = 0.01$ for unobscured circles in
 hexagon

$$\left(\frac{d}{L}\right)^2$$



if control area is also hexagonal, get $\left(\frac{d}{L}\right)^2$

in general, for other lattices such as

if control area is required to have some shape on the
 lattice element, get $\left(\frac{d}{L}\right)^2$

if shape of element is not some factor but the amount of
 area $\left(\frac{A}{L^2}\right)$

the two above to determine the number of
 control in sample surface.

3/18/64

7

A day or two ago, got phone call from Mr. Koenig who has a large analog computer in Engineering from behind the GEM store 949-3900

Computer belongs to Govt. They teach a course in systems engineering with it. Manufactured by Applied Dynamics, Inc. - 152 op. amplifiers, also function generators & multipliers.

Might be useful to me to explore ranges of parameters which keep system in same domain.

Yesterday, prepared rough draft of annual report.

Also prepared description of branch generation problem for Betty Gorker. She reports that program is presumed to be OK. but there is still an unresolved difficulty in getting plotter input.

On Third Thought (3/27/64), it may lead to too many complications to try to take care of anodal breaks & everything else. It may be better to keep model very simple for propagation calculations. This may not be the time to complicate this model.

Intuitively, it seems to me that anodal breaks would require changes such that $g \neq 0$ for resting conditions, hence, also, $E \neq 0$. Hence, also, might change normalization of V , but all this would lose much of the simplification.

Try, with present program, reducing $RINB$ by factor of 10
and $QENCB$ by factor of 10

to see if can raise threshold & also falling phase of spike.

3/26/64 Yesterday had lunch with Roshevsky & Zinn.
Conversation stimulated me to test my impulse
model further

for single path
$$\begin{aligned} r\dot{V} &= (1 + \epsilon + g)V + E + \beta g + \psi \\ &= \epsilon(1 - V) - g(V + \beta) - V + \psi \end{aligned}$$

$$r, V^3 \quad r\dot{E} = (RA)V^2 + (RB)V^4 - [(RC) + (RD)g]E$$

$$r\dot{g} = (RE)[(RC) + (RD)g]E - (RF)g$$

from p. 93 of Book 3, estimate ~~RC=20~~

$R_1 = RACT * RINB \approx 3 \times 10^4$ peak E ≈ 450
 $RC = ROUTB \approx 20$ peak g ≈ 50
 $RD = QENCHB / QENCHA \approx 3$
 $RE = QENCHA / RACT \approx 0.033$
 $RF = ROUTC \approx 3$

for $V = 0.01$, $r, V^3 = 3 \times 10^4 \times 10^{-3} = 30$
approx threshold.

want higher threshold so that $(RA)V^2 + (RB)V^4 \approx 30$
for $V \approx 0.25$

if $RB = 3 \times 10^4$
$$RB(0.25)^4 \approx (3 \times 10^4)(4 \times 10^{-2}) = 1200$$

$$RB(0.2)^2 \approx (3 \times 10^4)(16 \times 10^{-4}) = 48$$

Could start out by trying 3×10^4

8

$$\psi = \beta a + 3 + V(R) \psi = \psi$$

$$\psi = \psi - (\beta + V) \psi - (V - 1) \psi =$$

$$3[\beta(R) + \beta] - V(R) \psi - V(R) \psi = 3\psi$$

$$\beta(R) - 3[\beta(R) + \beta] - (R) \psi = \beta \psi$$

WXR605C first explored the area correction, but did this for XAJH as well as XAJH.

Then, when revised to WXR606C, removed the area correction XAJH → XASJL

and added the TH for TB change in conductance calculation

Can now delete WXR605C
+ later 604C + 68C

3/27/64

Things to do soon

Add giant extracellular to WXR791C (p.80 of Bk 3)

3 Question of threshold level in current cells with (791C) may want to use $k_1V^2 + k_2V^4$ instead of kV^3 (p.79 Bk3)

Note that on p.79, two cases almost suitable, but want A+B also, subst for .0669 by letter J.C. like .0659

Note point about anesthesia & facilitation for antidromic invasion on p.77 of Bk 3,

Should duplicate WXR791C, 91C, 92C, 82C because works well & now want to revise

? Also Tom Smith

Also, any new figures for Eccles Volume, ? Write Archie

Also, note: Recently successfully modified to get WXR666C WXR69C

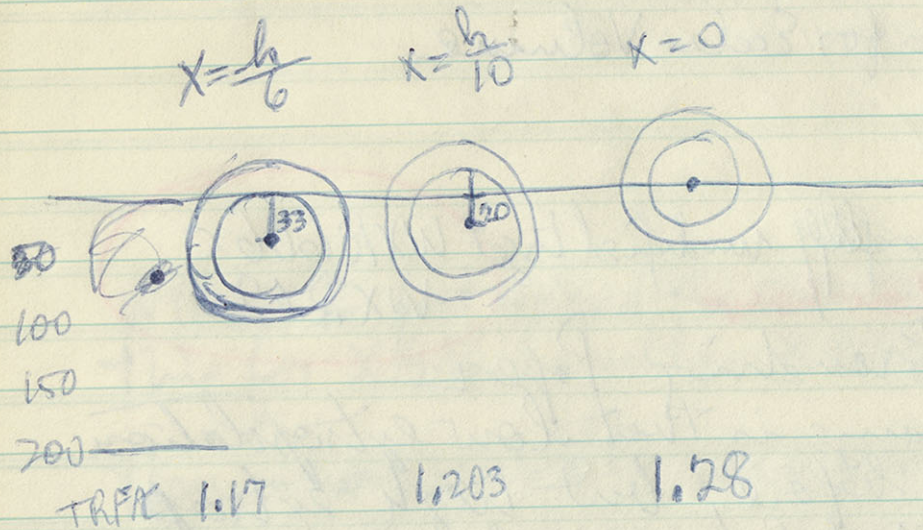
for Dantonia Branding Paper

The essential change is that slow extrapolation is as it was before, but high extrop now uses total seen for areas and for lengths, whenever this is larger than extrop from bifurcating (also ambig treated as ext)

Thus, for BINB, use $TH \neq \tanh(Z(J,5))$ when $Z(J,5) > Z(J,2)$

And for Area, use $XAJH = XASJH = ASJ * FACJH_{previous}$ when this exceeds $XAJH = FACJH_{current} * T * SPXL(J,2)$

(21/11/17)
(20/11/17)



3/30/64

Letter from Aitken says that ~~the~~ is prepared to regard perikaryon depth as unknown, but within the limits 200μ . "Cut cells would appear as fragments and were not counted."

I can see how the small piece is a fragment, but how about the large piece.

∴ using formula on page 84 of Bk 3

Conservative case $x = \frac{h}{12}$ gives $\bar{f} = 0.854$, TRFAC = 1.017

If $x = \frac{h}{10}$, corresp to 20μ , i.e. 15μ of 35μ radius cut off.

$$\text{Volume of spherical segment} = \frac{1}{3}\pi z^2(3r - z)$$

$$\text{Volume of sphere} = \frac{4}{3}\pi r^3$$

$$\frac{h^2(3r - z)}{4r^3}$$

$$z = 15\mu \rightarrow 3, \quad r = 35\mu \rightarrow 7$$

$$x = 20$$

$$\frac{9(21 - 3)}{4 \cdot 7^3} = \frac{9 \times 18}{28 \cdot 49} = \frac{162}{1372}$$

$$= \frac{81}{686} = 0.118$$

approx 12% vol.

$$h = 20, \quad x = 2, \quad b = 5$$

$$\bar{f} = \frac{\sqrt{(18)^2 + 5^2} - \sqrt{4 + 25}}{20 - 4}$$

$$= \frac{\sqrt{324 + 25} - \sqrt{29}}{16}$$

$$= \frac{18.69 - 5.38}{16}$$

$$= \frac{13.31}{16} = 0.832 = \frac{1}{1.203}$$

probability of cut perikaryon

$$\frac{13\mu}{80\mu} = 16\%$$

$$\text{uncut perikaryon} \left(\frac{67}{80} = 84\% \right)$$

#1, 16, 22, 57, 58

quite likely these are the ones whose
truncation happened to leave no reference
tree long enough to permit further
extrapolation. In that case, the longer
ones may be closer to the truth.

4/3/64

found yesterday, in examining Aitken's 10 neurons, that dendritic surface area percentages with order of branching are probably better expressed separately for two groups of five.

Trunks Prim Sec Terd Quat Quin Sex

Longer Cells 99 16 21 19 20 13 2

Shorter or More cutoff 18 31 34 17 0 0 0

Also discussed with Gordon at length about my old ditto where weighted mean of L/x is estimated from
$$\frac{\bar{L}}{\bar{d}} = \frac{\sum Ld}{\sum d^{3/2}}$$
 where $d^{3/2}$ is the weight.

wrote memo to Betty Garber about calc. of mean lengths.

Plan to write letter to Kathryn Thomas about above percentages.

Also, may wish to modify WXR 606C to provide $\frac{SD}{N}$ and $\frac{SL}{N}$ for all categories.

May need $\frac{SL}{N}$ & St. dev of lengths for comparison with the generated trees.

7/2/64

about 1000 in examining (Littell's) ...
that double surface area percentages with
order of magnitude or probably better expressed
separately for two groups of five.

Table 10 see Test Unit 20

Table 10
18 19 20 21 22

Table 10
18 19 20 21 22

Classified with Fisher's ...
old data were weighted mean of ...
from $\frac{1}{10} = \frac{2.16}{21.6}$

... to Fisher's ...
... to Fisher's ...

... to multiply with ... to ...
... and $\frac{1}{10}$ for all categories.

... for comparison with
the ...

4/7/64

Conversation with Jose began with relation between Laplace transform + Fourier transform.

Laplace transform mapping from half plane $\text{Re}(s) \geq 0$

then the factor e^{-st} can tame mild blow up of a fun

$$f(s) = \mathcal{L}\{F(t)\} = \int_0^{\infty} e^{-st} F(t) dt$$

suppose $F(t) = e^{at}$ which blows up as $t \rightarrow \infty$

and its transform, $\frac{1}{s-a}$ has a pole at $s=a$

therefore simple integration possible only for $s > a$,
and integration around the pole gives e^{at}

His point, was that if there is no pole for $s > 0$, then
can integrate along imaginary axis; ~~this is~~ then
this is exactly equal to the Fourier transform.

Then we got to talking about whether one can get
from a Bode diagram (which applies to A.C. steady state)
back to complete transform which gives transient solutions.
In principle, yes, because analytic fns in complex plane
are such that all can be recovered from a precise defn
in a small portion of complex plane. But what about
in practice. Our thought was, suppose we
set up a model which fits Bode, except we miss
a pole far out in ^{st. half of} complex plane. What will this error
do to the computed transient response?

Convergence with first term with vector later

then transfer to series transform

then transfer to series transform $R(z) \approx 0$

then the factor e^{-at} can be used with the transfer

$$F(s) = \int_0^\infty e^{-st} f(t) dt = \int_0^\infty e^{-st} e^{-at} f(t) dt$$

suppose $F(s) = e^{-as}$ which corresponds to $t \rightarrow \infty$

and its transform $\frac{1}{s-a}$ has a pole at $s=a$

then we can integrate with respect to s for $s > a$ and integration around the pole gives $2\pi i$

the pole was that if there is no pole for $s > a$, then can integrate along imaginary axis; ~~then~~ then there is a branch cut to the transfer transform.

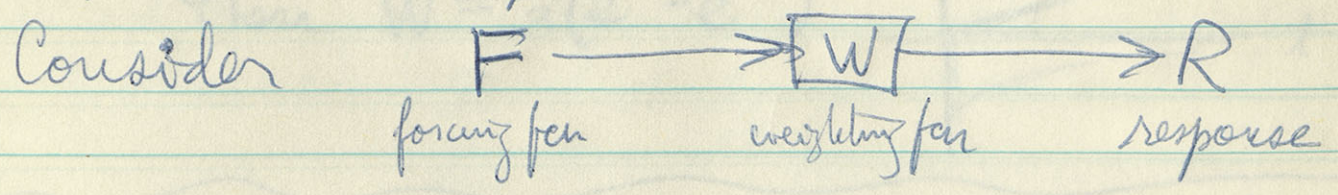
then we want to talk about what we can get from a Bode diagram (which applies to A.C. signals) jobs to complete transform which gives transient solutions. In principle, we have analysis from a complex plane and we can be reversed from a precise defn in a small portion of complex plane. But we are about in practice. Our transfer was, suppose we

$$R_{approx} - R = R' - (z+1)R$$

set up a model. But the Bode diagram is a pole located in a small portion of complex plane. due to the complex plane.

4/7/64

This led to the following conjecture about cancelling a pole in complex plane.



Suppose $L\{W\} = \frac{1}{(s+a)(s+b)(s-\lambda)}$

pole

Then pole will be cancelled for response, provided that $L\{F\}$ has $s-\lambda$ in the numerator

Say $L\{F\} = \frac{s-\lambda}{(s+c)(s+d)}$

Then $L\{R\} = \frac{1}{(s+a)(s+b)(s+c)(s+d)}$

which has no pole

This means that although $W(t)$ blows up $R(t)$ does not provided $F(t)$ fits above.

Also, now, if $L\{W_{approx}\} = \frac{1}{(s+a)(s+b)}$

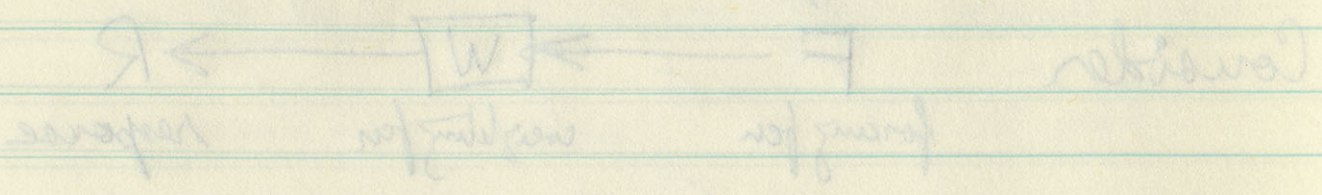
then $L\{R_{approx}\} = L\{F\} \cdot L\{W_{approx}\}$
 $= (s-\lambda) \cdot L\{R\}$

$R_{approx} = R' - \lambda R$

~~R_{app}~~

4/1/04

The last to the following conditions about cancelling a pole in complex plane:



Suppose $W(s) = \frac{1}{(s+1)(s-2)}$

There is a pole at $s=2$.

These poles will be cancelled in response, provided that $F(s)$ has $s-2$ in the numerator.

Let $F(s) = \frac{s-2}{(s+1)(s+3)}$

Then $R(s) = \frac{1}{(s+1)(s+3)(s+4)}$

which has no poles

Therefore the overall $W(s)$ blows up
 $R(s)$ also will
 cancel $F(s)$ poles

Also, note if $W(s) = \frac{1}{(s+1)(s+2)}$

then $R(s) = \frac{1}{(s+1)(s+2)(s+3)}$

$F(s) = \frac{1}{(s+1)(s+2)}$

$R_{total} = R \cdot F = \frac{1}{(s+3)}$

4/7/64

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e.g. suppose $\mathcal{L}\{W\} = \frac{1}{(s+1)(s-2)} = \frac{-1/3}{s+1} + \frac{1/3}{s-2}$

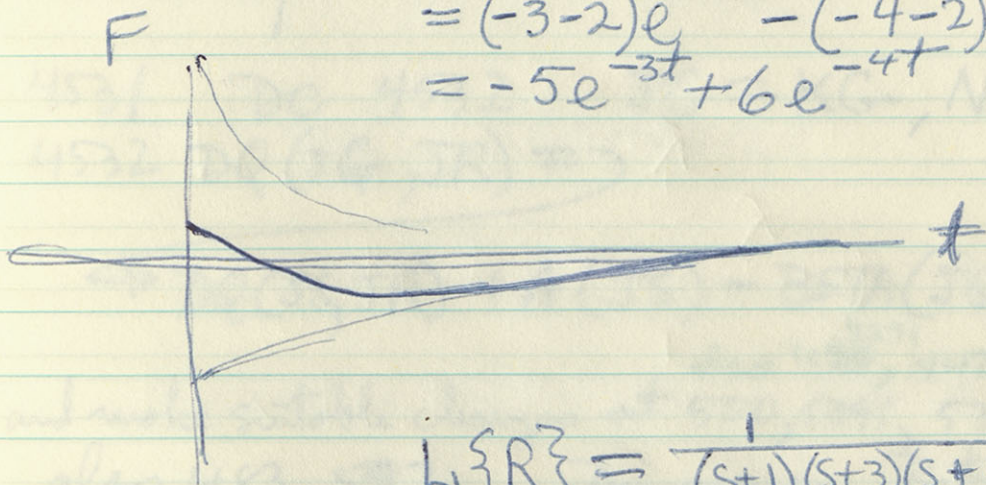
then $W = \frac{1}{3}(e^{2t} - e^{-t})$



Suppose $\mathcal{L}\{F\} = \frac{s-2}{(s+3)(s+4)} = (s-2)\left(\frac{1}{s+3} - \frac{1}{s+4}\right)$

$F = (s-2)(e^{-3t} - e^{-4t})$

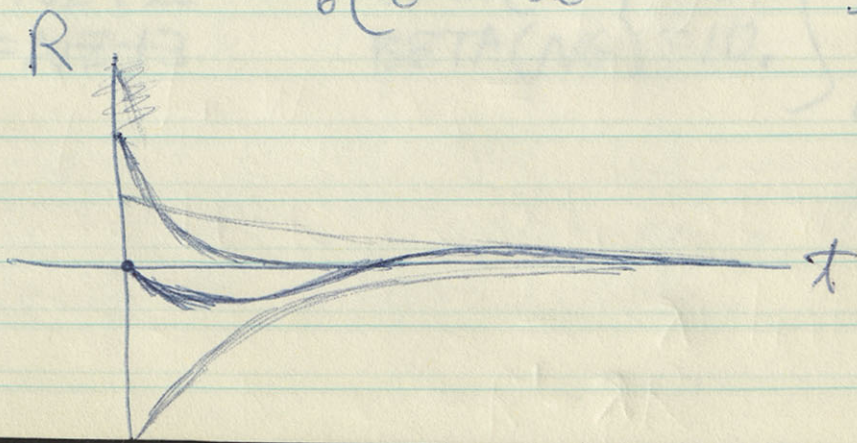
$= (-3-2)e^{-3t} - (-4-2)e^{-4t}$
 $= -5e^{-3t} + 6e^{-4t}$



$\mathcal{L}\{R\} = \frac{1}{(s+1)(s+3)(s+4)}$

$= \frac{+1/6}{s+1} - \frac{1/2}{s+3} + \frac{1/3}{s+4}$

$R = \frac{1}{6}e^{-t} - \frac{1}{2}e^{-3t} + \frac{1}{3}e^{-4t}$
 $= \frac{1}{6}(e^{-t} - 3e^{-3t} + 2e^{-4t})$



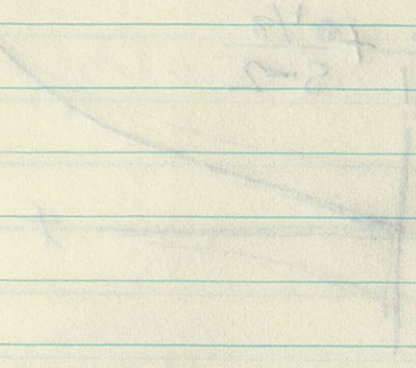
$$\frac{1}{s^2} = \frac{1}{s(s+0)} = \frac{A}{s} + \frac{B}{s+0}$$

$$1 = A(s+0) + B(s) = As + Bs$$

$$1 = (A+B)s$$

$$A+B=0$$

$$0s=1$$



$$\frac{1}{s^2+2s+1} = \frac{1}{(s+1)^2} = \frac{A}{s+1} + \frac{B}{(s+1)^2}$$

$$1 = A(s+1) + B = As + A + B$$

$$As + (A+B) = 1$$

$$A=0$$

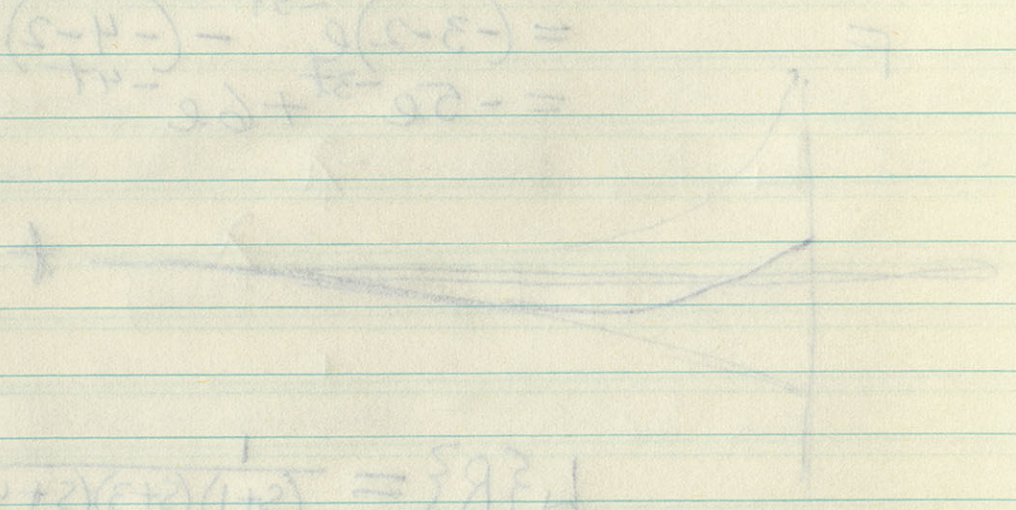
$$A+B=1$$

$$0+B=1$$

$$B=1$$

$$F = \frac{1}{(s+1)^2} = \frac{0}{s+1} + \frac{1}{(s+1)^2}$$

$$= \frac{1}{(s+1)^2}$$



$$\frac{1}{(s+1)(s+2)} = \frac{A}{s+1} + \frac{B}{s+2}$$

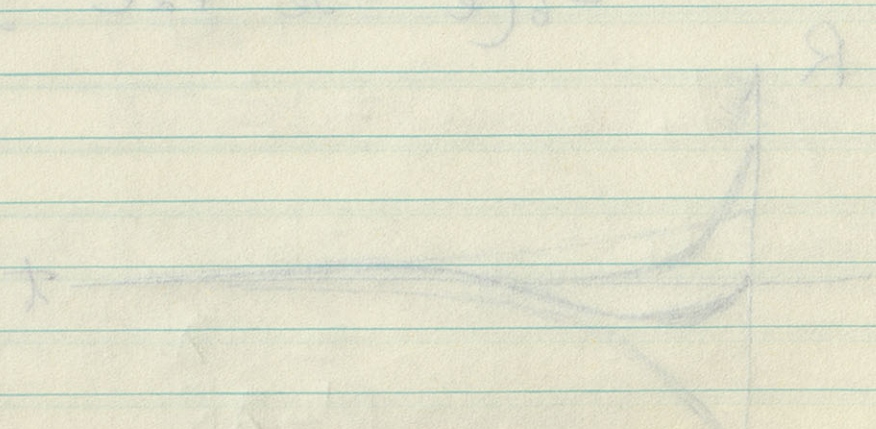
$$1 = A(s+2) + B(s+1) = As + 2A + Bs + B = (A+B)s + (2A+B)$$

$$A+B=0$$

$$2A+B=1$$

$$A=1$$

$$B=-1$$



4/15/64

WXR 793 C mod of 791 C
WXR 93 C mod of 91 C

Modified Main program & one Runge Kutta to achieve two purposes
I include Giant Extracellular
II Use V^4 for steeper onset

$$\frac{d}{dt}(V_g - V_e) = \frac{d}{dt}(V_i - V_e) + (V_i - V_e) - \beta(V_g - V_e)$$

Thus we put in WXR 93 C

4531 DO 4532 JG = KG, NG
4532 DQ (JG, JR) =

$$\rightarrow DQ(JS, JR) + A(JS) - \text{BETA}(JG) * A(JG)$$

and make suitable changes at 500, 5091, 530, 5391, 560, 5691
also 483, 582. Dimension Beta (14)

Equivolence (RINB, RBSQ), (RINC, RBFR)
might cause trouble

Define KG = NZ + 1 BETA(KG) = 2.0
 LG = NZ + 2 BETA(LG) = 5.0
 NG = NZ + 3 BETA(NG) = 10.0

} in main program
and add to argument

WXR P3C model
WXR P3C model

II Use V^H for step-up event
I include constant beta weight

$$\frac{1}{2}(V^H - V^L) = \frac{1}{2}(V^H - V^L) + (V^H - V^L) - \beta(V^H - V^L)$$

There are four WXR P3C

NEOS DE (28, 28) =>
NEOS DO NEOS 28 = KC, MG

$$\Rightarrow DE(28, 28) + A(28) - BETA(28) * A(28)$$

change in total charges of 200, 201, 230, 281, 250, 2811
also NEOS, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000

NE = NEH3
IG = NEH4
BETA(KC) = 2.0
BETA(IG) = 2.0
BETA(VE) = 10.0

4/16/64

WXR793C

16

First test did not work well: computed OK
made further corrections
also added G but no V^4 to 92C \rightarrow WXR94C

New test also did not work well, $V(JZ=2)$
does not seem to get anywhere.

4/20/64 putting in new tests with
 $NT=11$ and $IFTTEST=81$ or 11
for detailed checkout

Prepared abstract for J. Johnson

Wrote letter to Kathryn Thomas
(Minnesota)
summarizing area results.

Read but did not write comments on
Tavria's coupling coefficients.

Discussed + proof read manuscript
with Gordon Shepherd. Attempt
to complete next week.

4/21/64 WXR993C still not working well.

17

Most obvious difficulty is that DQ (JZ, JR) does not depart from zero for JZ from 2 thru JH

This test was in 94C, apparently 472 & 473 were not carried out.

Retest both in 791C & 793C
putting initial values in all compartments.
At least this will also provide test of GVe.
Also, will learn more about failure of 472 & 473

Eureka! I just found the trouble, argument of 94C & 93C was UA, UD, USA, USD from duplication of Call argument, whereas the subroutine was GA, GD, GSA & GSD.

Must either change argument or use equivalent statement.

Simplest to use equivalence
but might as well await the results of
this test, to see if GVe works &
also if V4 works.

4/21/84 WKRP3C will not working well.

Most obvious difficulty is that DP (25, 2R) does not report from base for 25 from station TH

That's not in room WTC, apparently. HTR473 was returned too.

Checked both in PIC & 193C putting in test values on all components. OK here, this will also provide set of G/K. Good, will have more about failure of HTR473

Trouble! I just found the trouble, argument of PIC 0282 was UA, UD, USA, USD from subroutine was GA, GD, GSA & GSD. duplication of cell numbers whereas the

Just either change equipment or use equivalent replacement. Sufficient to use equivalent. You might as well await the results of this test, to see if G/K works. Also if V1 works.

4/27/64

WXR793C

18

GVE worked for passive case, where still used cube function, but active case WXR 93C ~~showed~~ negative. Decided to eliminate Equivalence statement for RBSQ and RBFR and take care of this with arg.

GVE for Beta = 2. seemed to have too flat an after neg. Also, the scale changes for $LG = LG + NG$ were too restricted.

Change Beta (KG) = 5,
LG = 10,
NG = 20.

and keep all GVE plotting scales = .4 to .7

test put in today for FFVE = 1 for passive case
also test active case with repaired arg.

Worked out 4/25 + 4/24

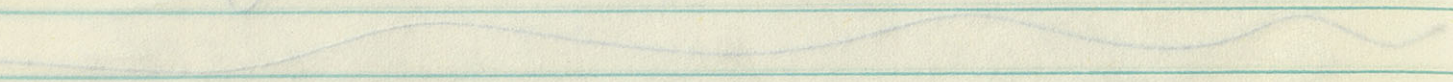
Made corrections 4/27

The worked for previous case, where
 address and function, but not
 case WXR 23C when register, tested
 to eliminate false alarm
 for RBSA and RBFK and other
 case of this with org.

GV for Beta = 2, seemed to have
 also list on other map. Also the
 scale changed for 2.5 = 1.5 km
 were too crowded.

- Change beta (K) = 2.
- KG = 10.
- MG = 20.

and keep all the other scales = 4.5
 not put in today for IVE = 1 for previous case
 also test other case with updated org.



4/23/64 - 4/27/64 WXR611C

19

Modified WXR606C to compute the
average & std. dev. of lengths

of prod & lengths & diam
for J, K

~~Also overall~~ Both for each cell &
for groups of cells divided by two funis
cards. Needs 3 funis cards at end.

NJCELL(JCELL) stores cell no. of a group.

Added many dimensions.

$$\text{Used formula } \text{Var}(x) = \frac{\sum x^2 - N \bar{x}^2}{N(N-1)}$$

$$\text{Thus } \text{VAR} = (\text{SDSQ}(J, K) - \text{AVD}(J, K) * \text{SD}(J, K)) / Y$$

where $Y \equiv N(N-1)$

Worked out 4/23 & 4/24
Made corrections 4/27

4/30/64

20

Problem 64793.0011

for $KVE=2$ compare soma extracellular Col 4
with giant (Beta=400) Col 11

at $KT=19$, giant ^{$V_g - V_{indiff.}$} corresp to 2 mV
soma V_e corresp to -1 mV

which agrees with $V_g - V_e = 3$ mV at this time

This implies that $\beta=400$ is far from negligible

ie. referring back to page 80 of Book 3

$$\beta = \frac{R_g + R_m}{R_g} \quad \text{where } R_g = AR_d$$

that $\frac{R_m}{R_g} \approx 400$ is far from negligible

In other words, a negligible R_g is $\ll R_m \times 10^{-3}$

However, convergence resistance may be sufficient to account for a negligible R_g & for a non-negl. R_g if R_m is reduced.

E/V_e shapes look very promising.

Problem 4.7.2, 0.11

1/10/14

for $R_{in} \gg R_g$ compare some circuit

at $R_T = 1 \mu$ $R_{in} \gg R_g$ $R_{in} \gg R_g$ $R_{in} \gg R_g$

which approx with $V_g = V_e = 3 mV$ at $R_T = 1 \mu$

the implies that $R_{in} \gg R_g$ is for from neglect

we refering back to page 80 of book 3

$R_{in} = R_g = A R_T$

that $R_{in} \gg R_g$ is for from neglect

the other words, a negligible R_g is $R_{in} \gg R_g$

Therefore, compare resistance must be sufficient to

$$\frac{dV_i}{dt} + \frac{V_i}{R_{in}^* C_m} = \frac{dV_g}{dt} + \frac{V_g}{R_g C_m} \quad \text{for } R_{in}^* \gg R_g$$

$$\boxed{\frac{dV_i}{dt} + \gamma V_i = \frac{dV_g}{dt} + \beta V_g} \quad \text{where } \gamma = \frac{R_{in}}{R_{in}^*}$$

$$\beta = \frac{R_{in}}{R_g} \left(\frac{R_{in}^* + R_g}{R_{in}^*} \right)$$

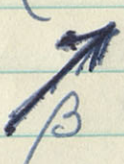
4/30/64 - 5/1/64

Giant Extracellular

21

for R_m normal, the D.E. is (for V_e as reference)

$$\tau \frac{dV_i}{dt} + V_i = \tau \frac{dV_g}{dt} + \left(\frac{R_m + R_g}{R_g} \right) V_g$$



 β

If $R_m \gg R_g$, then can use $\beta \approx \frac{R_m}{R_g}$

Suppose normal condition is something like $\beta = 10^4$

Suppose R_m falls by factor of 100 = γ
 then τ falls by factor of 100

by $T = t/\tau$ for normal τ

$$\text{Then } \tau^* \frac{dV_i}{dt} + V_i = \tau^* \frac{dV_g}{dt} + \left(\frac{R_m^* + R_g}{R_g} \right) V_g$$

multiply through by γ to get

$$\frac{dV_i}{dT} + \gamma V_i = \frac{dV_g}{dT} + \gamma \left(\frac{R_m^* + R_g}{R_g} \right) V_g$$

$$\text{To be exact, set } \frac{dV_i}{dT} + \frac{R_m}{R_m^*} V_i = \frac{dV_g}{dT} + \frac{R_m}{R_m^*} \left(\frac{R_m^* + R_g}{R_g} \right) V_g$$

But good enough approx is

$$\boxed{\frac{dV_i}{dT} + \frac{R_m}{R_m^*} V_i \approx \frac{dV_g}{dT} + \frac{R_m}{R_g} V_g}$$

for Giant, suppose

 10^2
 10^4

Spin... ..

4/30/64 - 2/1/64

for the normal, the D.F. is (for the normal)

$$\frac{1}{\sigma^2} + \frac{1}{\sigma^2} = \frac{1}{\sigma^2} + \left(\frac{R_m + R_0}{R_0}\right) \frac{1}{\sigma^2}$$

If $R_m \gg R_0$, then we can use $\beta \approx \frac{R_m}{R_0}$

Suppose normal condition is something like $\beta = 10^4$

Suppose the falls by factor of 100 = 8
then β falls by factor of 100

try $T = t/2$ for normal β

$$\frac{1}{\sigma^2} + \frac{1}{\sigma^2} = \frac{1}{\sigma^2} + \left(\frac{R_m + R_0}{R_0}\right) \frac{1}{\sigma^2}$$

multiply through by 8 to get

$$\frac{8}{\sigma^2} + 8 \frac{1}{\sigma^2} = \frac{8}{\sigma^2} + 8 \left(\frac{R_m + R_0}{R_0}\right) \frac{1}{\sigma^2}$$

$$\frac{1}{\sigma^2} + \frac{1}{\sigma^2} = \frac{1}{\sigma^2} + \left(\frac{R_m + R_0}{R_0}\right) \frac{1}{\sigma^2}$$

$$\frac{1}{\sigma^2} + \frac{1}{\sigma^2} = \frac{1}{\sigma^2} + \left(\frac{R_m + R_0}{R_0}\right) \frac{1}{\sigma^2}$$

10⁴

10²

for spin... ..

5/1/64 Plan to modify program to

Compute $\frac{dVg}{dT} = \frac{dVi}{dT} + \gamma Vi - \beta Vg$

where $\gamma = \frac{Rm}{Rm^*}$

Rm is normal
 Rm^* is abnormally reduced

and $\beta = \frac{Rm}{Rg} \left(\frac{Rm^* + Rg}{Rm^*} \right) \approx \frac{Rm}{Rg}$ for $Rm^* \gg Rg$

where β is normally of order 10^3 to 10^4

try $\beta = 10^4$ with $\gamma = 1, 10, 100, 1000$

2/1/64 Plan to modify program to
 Compute $\frac{\partial V_i}{\partial T} = \frac{\partial V_i}{\partial T} + \delta V_i - \beta V_i$

Remaining
 in a monthly period

$$\frac{R_m}{R_m^*} = \delta \quad 2/28/64$$

only $\beta = \frac{R_m}{R_d} \left(\frac{R_m + R_d}{R_m^*} \right)$ or $\frac{R_m}{R_d}$ for $\beta^* \rightarrow \beta$

where β is monthly interest rate

try $\beta = 10^4$ with $\delta = 1, 10, 100, 1000$

5/1/64 Summarize 64793

64793.0001 — .000576 developed program

64793.0006 proved that $NSTEP=2$ was too small for hot kinetics

64793.0007 first good GVe for passive case
also extracellulars $\beta = 2, 5, 10$.

64793.0008 good slightly delayed soma spike - passive case
 β values 320, 160, 80, 40, 20, 10

64793.0009 first successful active case $NSTEP=4$
GVe for $\beta = 100, 30, 10$

RBFR=120

Here, because of hot kinetics $\beta=30$ gave ≈ 80 mV ^{ped2} _{top2}
 $\beta=10$ gave >100 mV
 $\beta=100$ gave nearly 40

64793.0010A RBFR=80 soma blocked at 20 mV
because of no residual facil.

64793.0010B put residual facil in soma & dendrites
avoided block, quite good slope
good GVe for $\beta = 25, 50, 100, 200, 400$

64793.0011 passive case with residual facil.
 β values of 100, 200, 300, 400
Also extracellulars

2/1/84 Summary CH7P3

CH7P3.0001 - 0005 & developed program

CH7P3.0006 proved that NREF=2 works well for
last button

CH7P3.0007 first good file for pressure case
class of $\beta = 2, 5, 10$.

CH7P3.0008 good stable delay sensitive pressure case
values 300, 100, 80, 40, 20, 10

CH7P3.0009 first successful active case NREF=2
file for $\beta = 100, 50, 10$

REF=150
here, beam of last button $\beta = 30$ case 280 mV
 $\beta = 10$ case 210 mV
pressure case, nearly 10

CH7P3.0010A REF=80 same checked at 20 mV
because of no ventral fail.

CH7P3.0010B put ventral fail in some channels
checked the other, quite good slope
good file for $\beta = 22, 20, 100, 200, 400$

CH7P3.0011 pressure case with ventral fail.
values of 100, 200, 300, 400
class of $\beta = 2, 5, 10$

5/1/64

WXR 611C ~~is~~ worked fairly well on 4/30/64

got correct averages & st. deviations

However, group totals loused up when one of group has $JMP < JMPPOP$

Consolve this either by using only groups with all JMP the same, or better still,

~~at 830 DO 835 J=1, JMP~~

replace 830 with ¹⁰explicit do from J=1 to JMP

then set $J = \del{JMP}$ and $I = \del{JMP}$ and change J to I in last term of each of these expressions

~~The 145 at seq have to be DO J=1, 50~~

change JMPPOP to JOMPOP

and at 885 use J=1 to JOMPOP

and then use J=10

X=JCELL
PN=1/8

~~PSD(J,K)*RN~~

Do area extrop with $SD(J,K) = AVN(J,K) * AVD(J,K)$
 $SDXL(J,K) = AVN(J,K) * AVDXL(J,K)$
~~PSDXL(J,K)*RN~~

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get correct average of 21.4

However, group totals based up when
one of groups has 2MP < 2MP0P

Can solve this either by using only groups
with all 2MP the same, or better
still,

~~at 830 the cost is 2MP~~

replace 830 with appropriate from 21 to 20MP

then set $Z = I$ and $I = 2MP$

and change Z to I in last term of each of
these expressions

~~the effect of this is to~~

change 2MP0P to 2MP1P

and 830 was $Z = I$ to 20MP0P

and then was $Z = I$

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to give output with $20(2K) - 20(2K) + 20(2K)$
 $20(2K) - 20(2K) + 20(2K)$
W.R. Hill

5/6/64

on 5/5/64 oversan limit of number of fixed constants + non-dimensional variables

Took care of this, but on 5/6/64 still had to make a few small corrections

at 21 made $J=1, 10$ instead of 1, JMP because bin 10 was in trouble

at 542, 543, 544 restored PRED, PREXL

at 3221 set JOMP = JOMPOP

3222 $X = JCELL$

3223 $FN = 1./X$

because apparently $FN = 1/JCELL = 0$

Now hope for success.

Also had to change J to L in statement 837

Finally got good result 5/8/64

on 2/10/14 overran that I think of probably
 new dimensions and values for
 to be correct then, but on 2/11/14 with help
 to make a few small corrections

at 21 made 1-1, 10 instead of 1, 0MP

because but 10 was in trouble

at 212, 218, 241 instead of 212, 218, 241

at 3021 set 20MP = 20MP/P

3022 X = 1/CELL

3023 FN = 1/X

because apparently FN = 1/CELL = 0

More info for success

Observed to change 2 to 1 in 8/10/14

837

finally got good result 2/8/14

5/6/64 WXR 793 ~~was~~ compiled & worked
with Beta & Gamma
A-RBSQ, RBFR in 9HC

However, got blow up for some GVe;
suspect due to I.C. insomnia.

New runs will avoid this.

got interesting result comparing different
combinations of β & γ

$$\frac{\pi}{2} = 1.5708$$

$$\frac{2}{\pi} = 0.6366$$

2 Dimen

$$\frac{4}{\pi} = 1.2732$$

$$\frac{\pi}{4} = 0.7854$$

3 Dimen

5/8/64

Problem of Ratio: $\frac{\text{projected length}}{\text{true length}}$
of randomly oriented branches.

For branches lying in laminar planes, then answer is $\frac{2}{\pi}$

For branches dist. in three dimensions, answer is $\frac{\pi}{4}$

Betty Garbers first calc of tree 6 trunks, 6 borders
giving total of 378 elements

$$\frac{\text{True}}{Y-Z \text{ proj}} = 1.2547$$

$$\frac{\text{True}}{X-Z \text{ proj}} = 1.3049$$

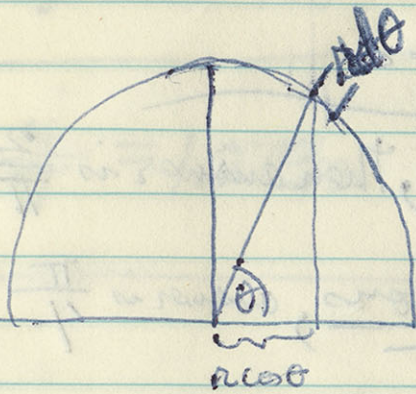
$$\frac{\text{True}}{X-Y \text{ proj}} = 1.2399$$

$$\begin{array}{r} 3 \overline{) 3.7995} \\ \underline{1.2665} \end{array}$$

which agrees rather well with $\frac{4}{\pi} = 1.273$

It was this numerical result which led me to clarify the difference between the 2-D and the 3-D assumptions. Long ago, both Ramon-Allelines and I had thought the $\frac{\pi}{2}$ answer was correct, because of the specious argument that a plane is a fair sample of 3-D.

2-D



Suppose N radii are distributed uniformly ~~to the point to~~ around the quarter circle

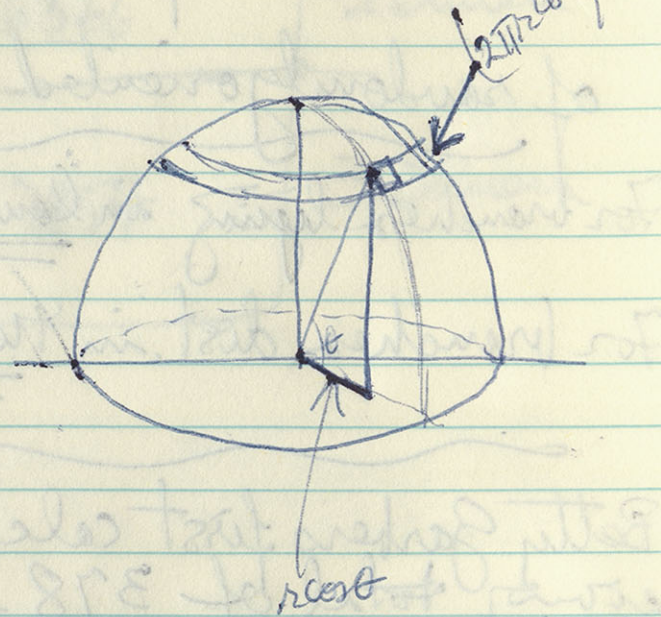
Then the number expected ~~from~~ between θ and $\theta + d\theta$ can be expressed

$$N \frac{d\theta}{\pi/2}$$

any arbitrarily chosen branch has a probability $d\theta / \frac{\pi}{2}$ of lying in this interval

The probability density (per radian) that any arbitrarily chosen branch will lie at any particular point is $\frac{2}{\pi}$ value of θ

3D



Suppose N points are dist. uniformly over the surface of the hemisphere

Then the number expected to lie in the surface annulus from θ to $\theta + d\theta$ can be expressed

$$N \frac{2\pi r^2 \cos \theta d\theta}{2\pi r^2}$$

any arbitrarily chosen branch has a probability $\cos \theta d\theta$ of lying in this annulus

The probability density (per radian) that any arbitrary point will lie at θ is $\cos \theta$

5/8/64

28

For any given instance, $l = r \cos \theta$, $\frac{l}{r} = \cos \theta$

To get the mean value of $\frac{l}{r}$, we must evaluate the integral

$$\text{mean } \frac{l}{r} = \int_0^{\pi/2} \cos \theta \cdot p(\theta) \cdot d\theta$$

where $p(\theta)$ is the probability density (per radian)

For the 2-D case, $p(\theta) = \frac{2}{\pi}$

$$\text{and mean } \frac{l}{r} = \int_0^{\pi/2} \frac{2}{\pi} \cos \theta d\theta = \frac{2}{\pi} \left[\sin \theta \right]_0^{\pi/2} = \frac{2}{\pi}$$

For the 3-D case, $p(\theta) = \cos \theta$

$$\begin{aligned} \text{and mean } \frac{l}{r} &= \int_0^{\pi/2} \cos^2 \theta d\theta = \left[\frac{\theta}{2} + \frac{\sin 2\theta}{4} \right]_0^{\pi/2} \\ &= \frac{\pi}{4} \end{aligned}$$

Apparent paradox: suppose we choose θ and ψ independently from uniform distributions, then $p(\theta)$ and $p(\psi)$ are both constants. But, then the resulting points are not uniform over the sphere; they are concentrated near the poles.

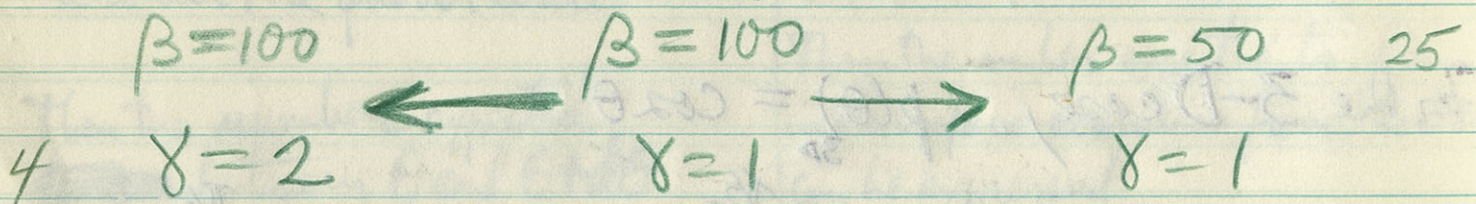
For any given instance, $L = 10 \cos \theta$, $\frac{L}{10} = \cos \theta$
 To get the mean value of $\frac{L}{10}$, we must evaluate the integral

$$\text{mean } \frac{L}{10} = \int \cos \theta \cdot p(\theta) \cdot d\theta$$

where $p(\theta)$ is the probability density function (pdf)

for the 2-D case, $p(\theta) = \frac{1}{\pi}$

Try



$$\left[\frac{1}{\pi} + \frac{1}{\pi} \right] = \frac{2}{\pi} = \frac{1}{\pi}$$

Special property: Suppose we choose θ out of independent
 random variables in distribution, then $p(\theta)$ and $p(\theta)$ are
 both constant. But from the constant pdf, we can
 see that the overall pdf is constant.

5/8/64

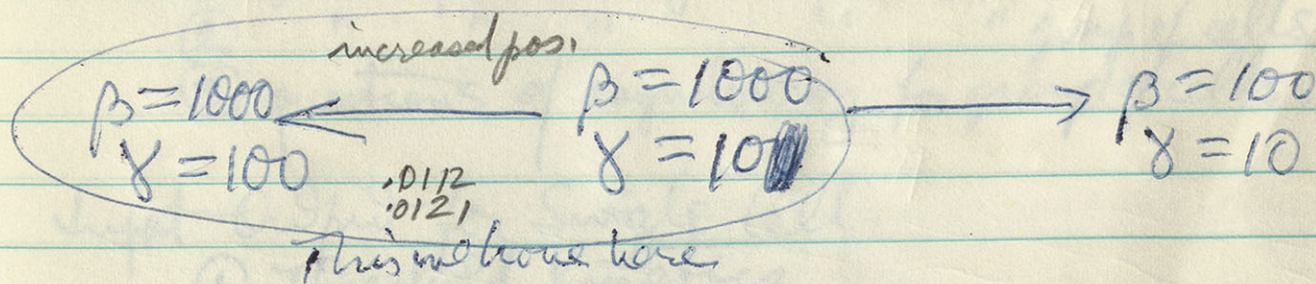
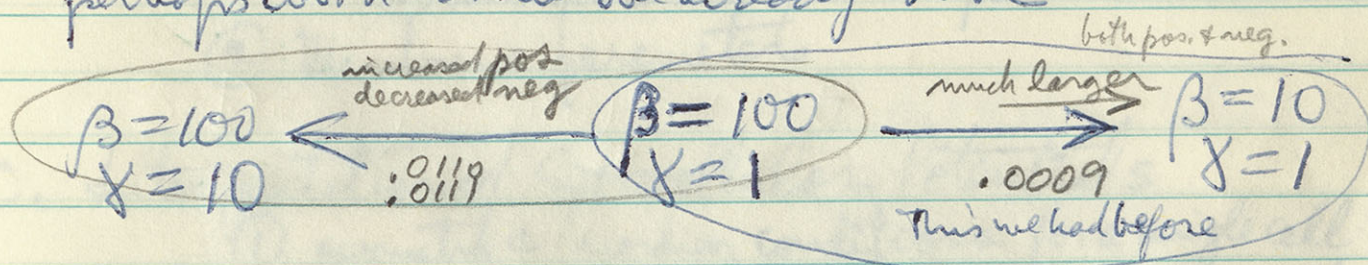
29

64793.0112 & ~~64793.0121~~

Did not avoid blowup with zero initial condition in soma. Apparently need to decrease Runge Kutta Step Size to handle such large values of β .

The intention was to begin with large β and compare the effects of $\left\{ \begin{array}{l} \text{decreasing } \beta \\ \text{increasing } \gamma \end{array} \right.$

Can use smaller stepsize. However may be useful to rephrase problem so that we compare perhaps with results we already have



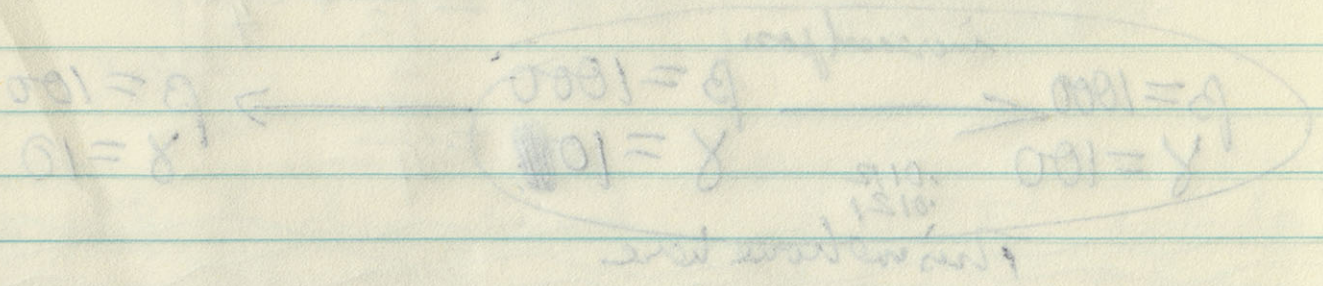
Maybe should use factors smaller than 10. Perhaps 2 or 4, once well centered.

4/15, 012, 011, 012

but not need to set up with some initial condition
inverses, opposite the need to decrease
large values of β .

The intention was to have with large β
and compare the effects of β increasing
and decreasing β .

Can we smaller step size, however may be
unable to replicate problem as that we compare
perhaps, with results which have



Maybe should use factors smaller than 10.
perhaps 2 or 4, once well entered.

5/11/64 Perspectives on Kinds of Problems: Math. Models & Neurophysiol

A. General Model of Neuron with different simplifications for different purposes.

- ① Geometric simplifications
 - (a) axon
 - (b) equivalent cylinder to class of dendritic trees
 - (c) specific types of dendritic trees.
- ② Simplifications of Membrane Kinetics.
 - (a) passive membrane
 - (c) step changes in parameters
 - (d) time varying resistances \propto on v & t .

B. Estimation of model parameters from intracell. data (on single cells).

- ① Geometric parameters
 - (a) interpretation of incomplete anatomical data
- ② Membrane parameters

C. Interpretation of Extracellular Potentials

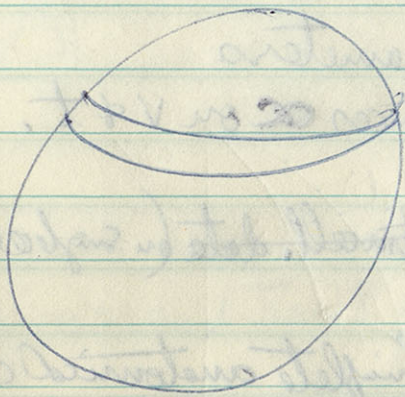
- ① geometry & recording conditions for a single cell
- ② " " " " " " " " group of cells
- ③ questions of asynchrony for group of cells.

D. Input-Output for Single Cell

- ① Threshold Kinetics
- ② Patterns of synaptic activity

E. Interactions ^{within} ~~of~~ Groups of Cells

F. Interactions between different groups of cells



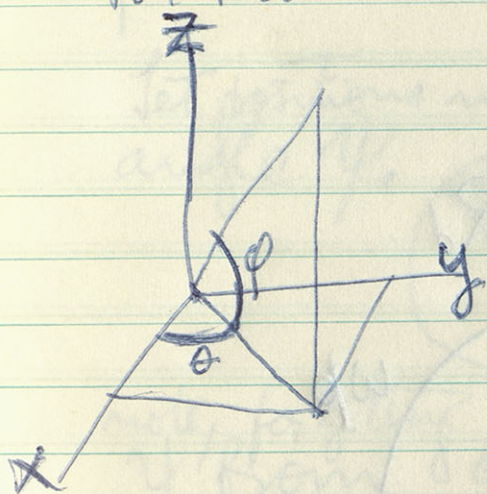
$$\begin{aligned}dA &= (2\pi R \cos \phi) R d\phi \\ &= 2\pi R^2 \cos \phi d\phi \\ &= 2\pi R^2 d(\sin \phi)\end{aligned}$$

uniform A means uniform $\sin \phi$

5/18/64 Gave talk to computer group on 5/13/64

Also worked on problem of having orientations equally probable wherever they are supposed to be. Roughed this out 5/14/64 and presented notes to Betty Garber on 5/15/64. However, there was an error. Here now correct.

For Franks



ϕ is latitude

θ is longitude

$$x = R \cos \phi \cos \theta$$

$$y = R \cos \phi \sin \theta$$

$$z = R \sin \phi$$

These are the symbols used in program.

Before 5/15/64, the original program chose

ϕ from a uniform dist from 0 to 2π

θ " " " " " " 0 to π

Also, one of daughter direction cosines was chosen from a uniform distribution.

Revised program

Let RAND be random number from 0 to 1.

$$\text{Let } \theta = 2 \cdot \pi \cdot \text{RAND}$$

$$\text{Let } \sin \phi = 2 \cdot \text{RAND} - 1.$$

also sin φ uniform

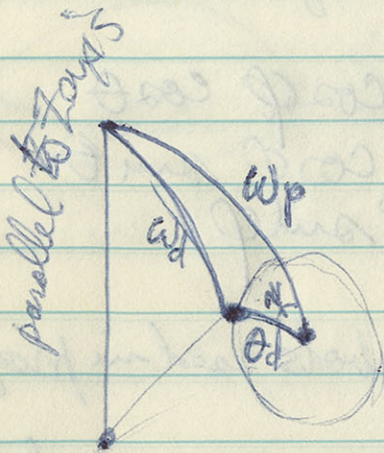
new
random
numbers

for nth node

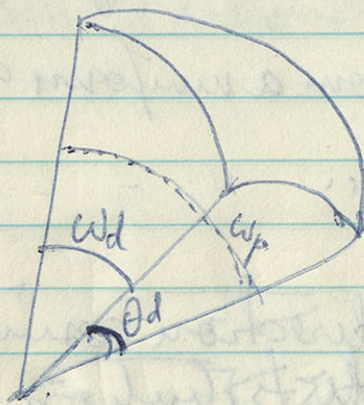
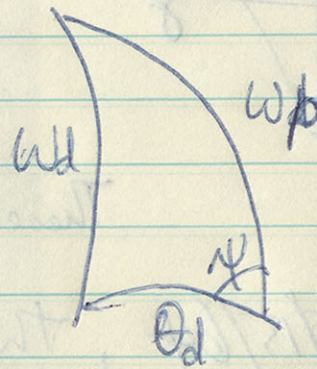
$$\alpha_m = \frac{x_m - x_p}{R_m}$$

$$\beta_m = \frac{y_m - y_p}{R_m}$$

$$\gamma_m = \frac{z_m - z_p}{R_m}$$



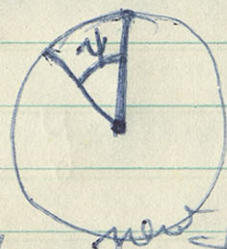
sphere of radius R_d



Suppose parent branch has direction cosines α_p , β_p and γ_p

For a given daughter, use up two degrees of freedom to get θ_d and ϕ_d which define a circular locus of equally probable locations for daughter node.

Let positions in this circle be represented by the angle ψ .



$$\text{Let } \psi = \pi * \text{RAND}$$

note, for getting directional cosine, need only consider ψ from 0 to π .

Given γ_p calculate γ_d

Correct answer is from spherical trig.

$$\cos \omega_d = \cos \omega_p \cos \theta_d + \sin \omega_p \sin \theta_d \cos \psi$$

$$\gamma_d = \gamma_p \cos \theta_d + \sin \omega_p \sin \theta_d \cos(\pi * \text{RAND})$$

$$\text{where } \sin \omega_p = +\sqrt{1 - (\gamma_p)^2}$$

Alternatively, same thing could be done for α_d rel to α_p or β_d rel to β_p , but then the other two direction cosines are defined

$$a = 1 + \left(\frac{\delta p}{\beta p}\right)^2$$

$$b = -2\delta p (\cos \theta d - \alpha p \alpha d) / \beta p^2$$

$$c = \alpha d^2 = 1 + \left(\frac{1}{\beta p}\right)^2 (\cos \theta d - \alpha p \alpha d)^2$$

Simpler if multiply each term by $(\beta p)^2$

The two equations are:

$$\alpha_p \alpha_d + \beta_p \beta_d + \gamma_p \gamma_d = \cos \theta_d$$

where θ_d
is angle between
daughter & parent

$$\alpha_d^2 + \beta_d^2 + \gamma_d^2 = 1$$

Suppose α_d and θ_d have been determined

Then solve 1st eqn for β_d in terms of γ_d and subst in 2nd.

ie.
$$\beta_d = \frac{1}{\beta_p} (\cos \theta_d - \alpha_p \alpha_d - \gamma_p \gamma_d)$$

$$\begin{aligned} \gamma_d^2 &= 1 - \alpha_d^2 - \beta_d^2 \\ &= 1 - \alpha_d^2 - \left(\frac{1}{\beta_p}\right)^2 \left((\cos \theta_d - \alpha_p \alpha_d)^2 - 2(\gamma_p \gamma_d) + \gamma_p^2 \gamma_d^2 \right) \end{aligned}$$

$$\gamma_d^2 \left(1 + \frac{\gamma_p^2}{\beta_p^2}\right) = \frac{2\gamma_p (\cos \theta_d - \alpha_p \alpha_d) \gamma_d}{\beta_p^2} + \alpha_d^2 - 1 + \left(\frac{1}{\beta_p}\right)^2 (\cos \theta_d - \alpha_p \alpha_d)^2$$

Quadratic formula.

$$\gamma_d = \frac{+2\gamma_p (\cos \theta_d - \alpha_p \alpha_d) \pm \sqrt{4\gamma_p^2 (\cos \theta_d - \alpha_p \alpha_d)^2 - 4ac}}{2\left(1 + \frac{\gamma_p^2}{\beta_p^2}\right)}$$

mult by β_p^2

$$= \frac{\gamma_p (\cos \theta_d - \alpha_p \alpha_d)}{1 - \alpha_p^2} \pm \beta_p \frac{\sqrt{(1 - \alpha_p^2)(1 - \alpha_d^2) - (\cos \theta_d - \alpha_p \alpha_d)^2}}{1 - \alpha_p^2}$$

The two equations are:

$$\begin{aligned}
 x^2 + bx + c &= 0 \\
 x^2 + px + q &= 0
 \end{aligned}$$

Suppose α and β are the roots of the first equation

Then we let α be a root of the first equation

$$\alpha^2 + b\alpha + c = 0$$

$$\alpha^2 = -b\alpha - c$$

$$\alpha^2 + p\alpha + q = 0$$

$$(-b\alpha - c) + p\alpha + q = 0$$

$$\alpha(p - b) + (q - c) = 0$$

$$\alpha = \frac{c - q}{p - b}$$

5/20/64

Stock taking.

34

- ① Have corrected randomizers for Betty Garber's program
- ② Noticed error ~~at~~ in WXR611C which confused JMP#10 at one point giving peculiar output for individual totals. This should be fixed. Then, should get runs for two groups & maybe for one overall group.
- ③ Should do giant V_e runs as noted on p. 29
- ④ Want to write up kinetic model now
- ⑤ Must finish off ~~papers~~ papers soon.
- ⑥ Must discuss late Mitral & other cells of Gordon's records re? simulation

cf. P. 93 of Book 3

In 64791.0647

peak $E \approx 450$ with $g \approx 10$

later peak $g \approx 50$ with E down to about 12

In 64793.0112 & .0121

RACT = 500.

RBSQ = 1.

RBPR = 80.

QA = 15.

ROUTB = 20.

ROUTC = 5.

QB = 40.

AFPOS = .1 in. ($\beta = -.1$)

5/21/64

Kinetics of uniform membrane patch

$$\tau \dot{V} = I_m R_m - V + E(V_e - V) - g(V - V_j)$$

where $V = V_m - E_r = V_i - V_e - E_r$

$$V_e = E_e - E_r$$

$$V_j = E_j - E_r$$

$$\psi = \frac{I_m R_m}{V_e}$$

divide thru by V_e & let $y = \frac{V}{V_e}$ and $\beta = \frac{V_j}{V_e}$

Then

$$\tau \dot{y} = \psi - y + E(1 - y) - g(y - \beta)$$

And current kinetic model has

$$\tau \dot{E} = k_1 y^2 + k_2 y^4 - (k_3 + k_4 g) E$$

$$\tau \dot{g} = k_5 (k_3 + k_4 g) E - k_6 g$$

WXR793C

where in 5/6/64 version of WXR93C & 94C

E corresp to B * RACT
g " " C * QENCHA

$k_1 = RACT * RBSQ$	\longrightarrow	500.	
$k_2 = RACT * RBFR$		4×10^4	
$k_3 = ROUTB$		20.	
$k_4 = QB/QA$		2.667	$\frac{40}{15}$
$k_5 = QA/RACT$.03	$\frac{15}{500}$
$k_6 = ROUTC$		5.	

kinetics of water in anodic process

$$i = i_0 \left(\frac{V}{V_0} \right)^{\alpha} - i_0 \left(\frac{V_0}{V} \right)^{\beta} + V - V_0 = 0$$

$$i = i_0 \left(\frac{V}{V_0} \right)^{\alpha} - i_0 \left(\frac{V_0}{V} \right)^{\beta} + V - V_0 = 0$$

$$V_0 = E_0$$

divide through by i_0 and let $y = \frac{V}{V_0}$ and $\psi = \frac{V - V_0}{V_0}$

$$y^{\alpha} - y^{-\beta} + y - 1 = \psi \quad (1)$$

and current becomes constant

$$\begin{cases} \alpha y^{\alpha-1} - (-\beta) y^{-\beta-1} + 1 = \psi' & (2) \\ \beta y^{-\beta-1} - \alpha y^{\alpha-1} = \psi' & (3) \end{cases}$$

This presumably ^{would correspond to a} shift of my E_0 toward E_c



But then a model electrotonus is not absolutely passive & not absolutely linear

Consider programming for a study of these kinetics

Should print $y, z, g, I+E+g$

for (A) action potential

(B) for voltage clamp

(C) for small constant current

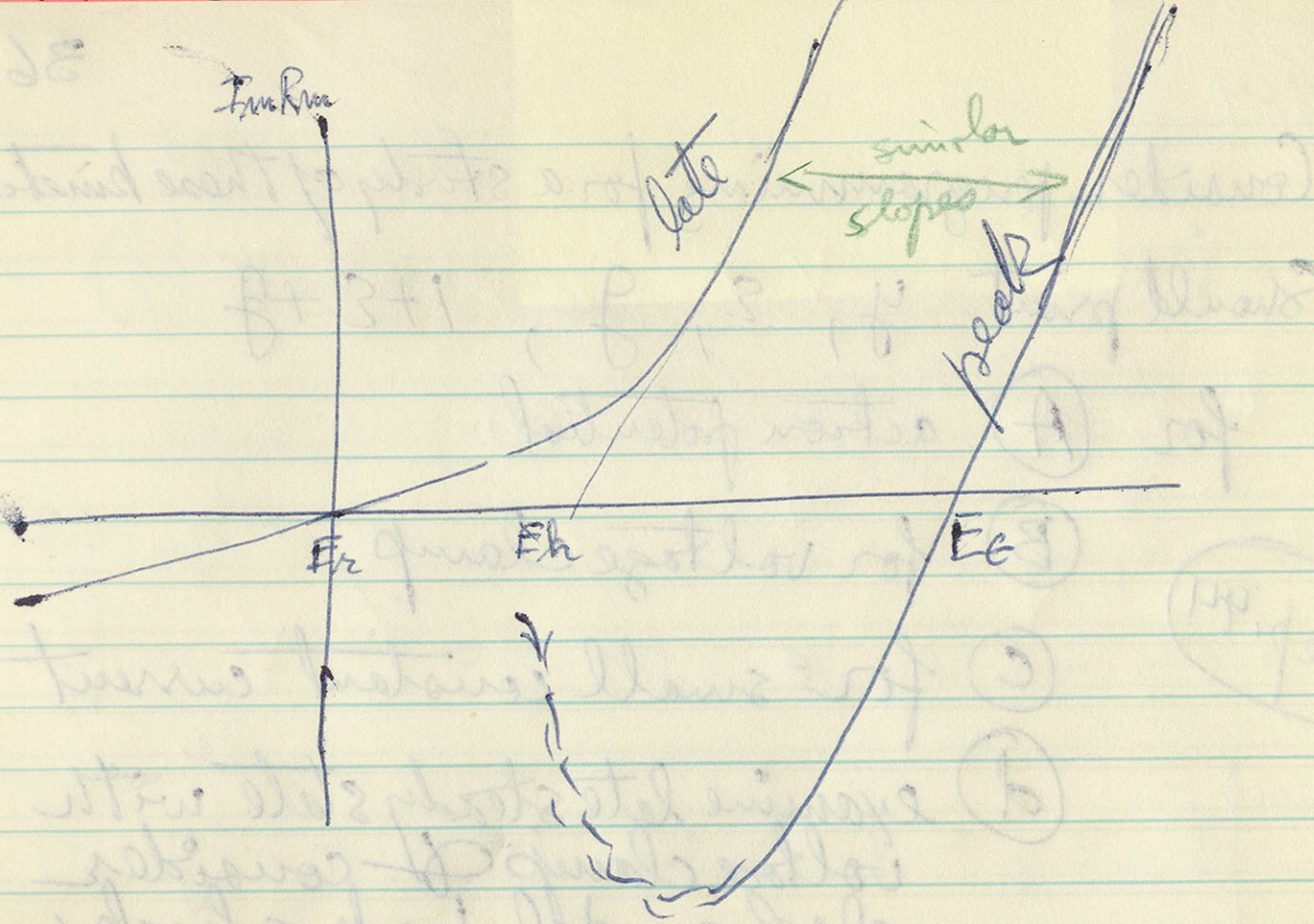
(d) examine late steady state with voltage clamp & consider also anodal break shocks

see p. 44

Problems become apparent as one tries to satisfy all these requirements with a single simplified model. But several points of interest are suggested.

(1) If want purely passive response to anodal stimuli, then must have k_1 and k_2 be zero for $y < 0$. Can do with Heaviside function, if desired. However, then do not get anodal break response. H&H apparently do this by swinging m and h below ^{toward zero} rest values. This I cannot do with g which is zero at rest. I could have a very small increase of E to mimic this.

(2) If we wish the equations to predict st. state resp. to depol. voltage clamp, there seems



From Eq(1), for $\dot{y} = 0$

$$\psi = (1 + \epsilon + \eta)y - \epsilon - \beta\eta$$

$$= (1 + \epsilon + \eta)y - (\epsilon - 0.1\eta)$$

intercept
 $\psi = 0$

$$y = \frac{\epsilon - 0.1\eta}{1 + \epsilon + \eta}$$

where ϵ & η are fcn's of steady y .

~~Having to that $(\epsilon - 0.1\eta)$ becomes indpt of y~~

Presumably $\frac{\epsilon - 0.1\eta}{1 + \epsilon + \eta}$ becomes indpt of y for $y \gg y_h$
 see p 411

to be a problem in matching H&H concept of late g_K dominating over late g_{Na} , but maybe p. 456 of H&H paper ②

wise not to assume I_{Na} makes no contribution.

In fact, it seems to me that the late st. st. current voltage characteristic might well benefit by alternative interpretations.

is. if E is not negligible, then the reference point for chord conductance is not E_j but a linear combination of E_j, E_r & E_c .

To me, there has always seemed (see voltage clamp notes & manuscript re Frank, Furber & Nelson) to be something odd about the late st. st. $I \cdot V$ plot having same slope as peak plot, but with an extrapol intercept near E_c .

The notion that all these points are related to E_j by different chord conductances (Hagiwara & Saito) always seemed a little odd. This problem is worth looking into in present context.

take a further...
 late...
 map...
 p. 115 of H.H. paper.
 were not to assume the...
 defect...
 is if...
 the reference...
 no...
 Fig. 1.

there has been...
 take something...
 10%...
 the...
 seemed a little...

It may be necessary to consider eq (4) as an alternative to eq (3)

$$\textcircled{4} \quad \dot{x}j = k_7 E + k_8 j y - k_6 j$$

this gives the desired delayed start

this permits st. st. j to remain raised with steady y even after E has fallen back from a peak

$$k_7 \approx k_3 k_5 \approx 0.6$$

$$k_8 \approx k_4 k_5 (\text{peak } E) \approx (0.08)(450) \approx 36$$

Now, let us compare the late steady state of these two cases.

For equations (2) & (3) when $\dot{E} = 0 = \dot{j}$

we have
$$\frac{k_6}{k_5} j = (k_3 + k_4 j) E = k_1 y^2 + k_2 y^4 = R(y)$$

$$j = \frac{k_5}{k_6} R(y)$$

and
$$E = \frac{R}{k_3 + k_4 j} = \frac{R}{k_3 + \frac{k_4 k_5}{k_6} R}$$

$$k_{5/R6} = \frac{.03}{5} = .006$$

$$\xi = \frac{R}{20 + 2.67R}$$

It may be necessary to consider the relationship to eq (3)

things are the desired delayed state

The point is that if the system is not stable, the system will not be stable after 3 or 4 steps

$$k_1 = k_2 k_3 = 0.06$$

$$R_8 = k_1 k_2 (k_3 k_4) = (0.06)(1.20) = 0.072$$

Now let us compare the late steady state of these two cases

for operation (2) & (3) when $\xi = 0 = \dot{y}$

$$\frac{R_8}{R_6} = (k_3 + R_4) \xi = k_1 k_2 + k_3 y^2$$

$$\dot{y} = \frac{R_8}{R_6} R_4$$

$$\xi = \frac{R_8}{R_6 + R_4} = \frac{R_8}{R_6 + R_4}$$

$$R = 500y^2 + 4 \times 10^4 y^4$$

39

$$y = 0.5$$

$$y = 1$$

$$R = 125 + 2500 = 2625$$

$$R \approx 4 \times 10^4$$

$$g = 15.7$$

For Eqs (2+3)

$$g = 2.4 \times 10^2 = 240$$

$$E = \frac{2625}{20 + 41.9} = 42.5$$

$$E = \frac{4 \times 10^4}{20 + 640} = \frac{60}{58.8}$$

$$\frac{E - 0.1g}{1 + E + g} = \frac{42.5 - 1.57}{59.2}$$
$$\approx \frac{40.9}{59.2} = 0.69$$

$$\frac{E - 0.1g}{1 + E + g} = \frac{58.8 - 24}{299.8}$$
$$\approx \frac{34.8}{300} = 0.116$$

$$\psi = (0.5)(59.2) - 40.9$$
$$= 29.6 - 40.9$$
$$= -11.3$$

$$\psi \approx 300 - 0.116 \approx 300$$

Looks like E is too large
to fit desired constraints

Looks like E is too small
to fit desired constraints

Another possibility is

$$\textcircled{5} \quad \varepsilon_j = k_5 (k_3 + k_4 g) \varepsilon + k_8 g y - R_6 g$$

Then for st.

$$g \left(\frac{R_6 - k_8 y}{k_5} \right) = (k_3 + k_4 g) \varepsilon = R(y)$$

$$\text{Then } g = \left(\frac{k_5}{R_6 - k_8 y} \right) R$$

$$\varepsilon = \frac{R}{k_3 + k_4 g}$$

But not much better

For equations (2) & (4) when $\dot{E} = 0 = \dot{J}$

from (4) $E = \frac{1}{R_7} (R_6 - R_8 y) J$

from (2) $k_1 y^2 + k_2 y^4 = (R_3 + k_4 J) \left(\frac{R_6 - R_8 y}{R_7} \right) J$

$$R = \frac{R_3}{R_7} (R_6 - R_8 y) J + \frac{R_4}{R_7} (R_6 - R_8 y) J^2$$

$$J^2 + \frac{R_3}{R_4} J - \frac{R_7 R}{R_4 (R_6 - R_8 y)} = 0$$

$$J^2 + (7.5) J - \frac{(0.225)}{(5 - 36y)} R = 0$$

$y = 0.5$

$y = 1$

$$J^2 + 7.5 J = \frac{(0.225)(2625)}{(18 - 5)} = 0$$

$$J^2 + 7.5 J = \frac{(0.225) \times 4 \times 10^4}{-31} = 0$$

Trouble here because $R_8 y > R_6$ implies E negative

Avoid this trouble by making $R_6 = 10$ and $R_8 = 5$

approx $J^2 + 7.5 J - 80 = 0$
approx $(J + 13.3)(J - 6) = 0$

approx $J^2 + 7.5 J - 1800 = 0$
approx $(J + 46.5)(J - 39) = 0$

$J \approx 6$
 $E \approx 60 J$

$J \approx 39$
 $E \approx 10 J$

$$\text{If } \epsilon - 0.1q = (0.2)(1 + \epsilon + q)$$

$$\text{then } 4\epsilon = 1 + (1.5)q$$

$$\epsilon = 0.25 + 0.375q$$

$$\frac{d\epsilon}{dq} = 0.375 \frac{dq}{dq}$$

$$1 + \epsilon + q = 1.25 + 1.375q$$

If oversimplify require (see page opposite p. 37)

$$\begin{cases} 1 + \epsilon + \eta = K & \text{const max slope} \\ \epsilon - 0.1\eta = (0.2)(1 + \epsilon + \eta) = 0.2K \end{cases}$$

Then can solve $\begin{cases} \epsilon + \eta = K - 1 \\ \epsilon - 0.1\eta = 0.2K \end{cases}$

to get $\begin{cases} \eta \approx 0.73K - 0.91 \\ \epsilon \approx 0.273K - 0.091 \end{cases}$

Which is obviously too simple to serve the purpose. for all $y > y_h$

However, more generally, ϵ & η are st.st. f of y clamped

$$\begin{aligned} \text{and } \frac{dy}{dy} &= (1 + \epsilon + \eta) + \left(\frac{d\epsilon}{dy} + \frac{d\eta}{dy}\right)y - \frac{d\epsilon}{dy} - \beta \frac{d\eta}{dy} \\ &= 1 + \epsilon + \eta + (y-1)\frac{d\epsilon}{dy} + (y-\beta)\frac{d\eta}{dy} \\ &\approx K \text{ for } y > y_h \end{aligned}$$

~~also $1 + \epsilon + \eta \approx 5(\epsilon + \beta\eta)$ or $\epsilon = \frac{1 + (1-\beta)\eta}{4}$~~

~~$\begin{aligned} \therefore K &\approx 5(\epsilon + \beta\eta) + (y-1)\frac{d\epsilon}{dy} + (y-\beta)\frac{d\eta}{dy} \\ &\approx 1.25 + 1.375\eta + [(y-1)(0.375) + (y-\beta)]\frac{d\eta}{dy} \\ &\approx 1.25 + 1.375\eta + (2y - 0.275)\frac{d\eta}{dy} \end{aligned}$~~

May resolve by noting that \longrightarrow
 This "keto" curve does not correspond to
 a true st. st. but more nearly to
 a peak of current. Check this out
 with my model.

for y from 0.6 to 1.5 range
 Would like

$$\frac{dI}{dy}(y+0.1) + \frac{dE}{dy}(y-1) \approx 99 - \varepsilon - g$$

\uparrow \uparrow
 7 to 1.6 -0.4 to +.5

Consider

$$gy + 0.01g + \varepsilon y - \varepsilon - 99y = \text{const.}$$

diff with respect to y gives above

5/22/64

42

The H & H approach was to assume late G due to G_K and match G_K st-st as a fun of V to the data.

Here, the attempt has been to see if could get reasonable volt. clamp st-st. on the assumption that both ϵ & g contribute. But first attempt has not worked out.

for H & H data, $K \approx 100$

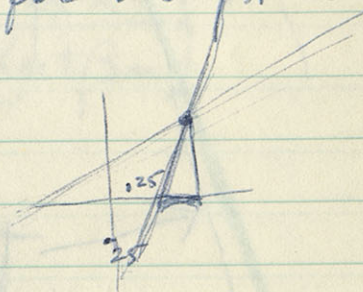
$$y_h \approx 0.25$$

would imply that

$$\psi_{intercept} \approx -25$$

this would imply

$$\epsilon - 0.1g = 25$$



Note st-st. ϵ & st-st. g would be fun of y

for any given $y_1 \approx 0.6$ we can only say that $\psi_1 \approx 100(y_1 - 0.25)$

$$y_1 = \frac{\psi_1}{100} + 0.25$$

$$\text{Thus } \psi_1 = 100(y_1 - 0.25) \approx (1 + \epsilon_1 + g_1)y_1 - (\epsilon_1 - 0.1g_1)$$

$$\text{and } \psi_2 = 100(y_2 - 0.25) \approx (1 + \epsilon_2 + g_2)y_2 - (\epsilon_2 - 0.1g_2)$$

It is not true in general, that $1 + \epsilon + g = 100$ and that $\epsilon - 0.1g = 25$ if it were, ϵ & g would have fixed values as in the upper half of p. 41

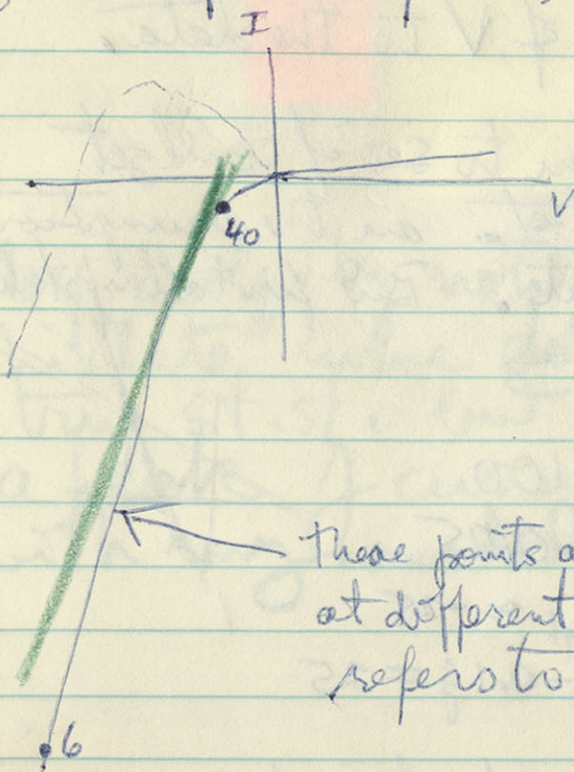
But for $y_1 > 0.6$, we say that $\frac{d\psi}{dy} \approx 100$

$$\frac{d\psi}{dy} = 1 + \epsilon + g + (y-1)\frac{d\epsilon}{dy} + (y+0.1)\frac{dg}{dy} \approx 100$$

For very rough approx, assume $\frac{d\epsilon}{dy}$ negligible

$$\text{then } (y+0.1)\frac{dg}{dy} + g \approx 100 - 1 - \epsilon = 99 - \epsilon$$

Fig 13 exp. 439 of H, H & K



These points are labeled as having been obtained at different points in time, and text refers to a "steady state"

range from 6 msec to 40 msec

↑
because peaks earlier

↑
because slow approach

If all were taken at same time, say 10 or 15 sec,
the top bend would go straighter to an intercept
and the bottom points would shift up.

5/22/64

Relevant conclusion this afternoon is that not likely to get started with my simple model. After all, in H & H paper five, their relation which would correspond roughly to my g vs y sought, is

$$\frac{g_{K_{ss}}}{g_{K_{max}}} = (N_{ss})^4 = \left(\frac{\alpha_m}{\alpha_m + \beta_m} \right)^4$$

$$\text{where } \alpha_m = \frac{0.01(V+10)}{\exp(0.1(V+10)) - 1}$$

$$\text{and } \beta = 0.125 \exp(V/80)$$

(p. 510 & 511 of paper 5)

However, note that H & H do not fit a true experimental steady state themselves;

They seem to use a peak K current, the late conductance curve would look different if all points were obtained for the same time value in the voltage clamping transients.

See left page

∴ attempt of previous pages was too severe.

The suspicion I wish to check is that peak K current corresp to a significantly non-zero ϵ and that, perhaps, the value of

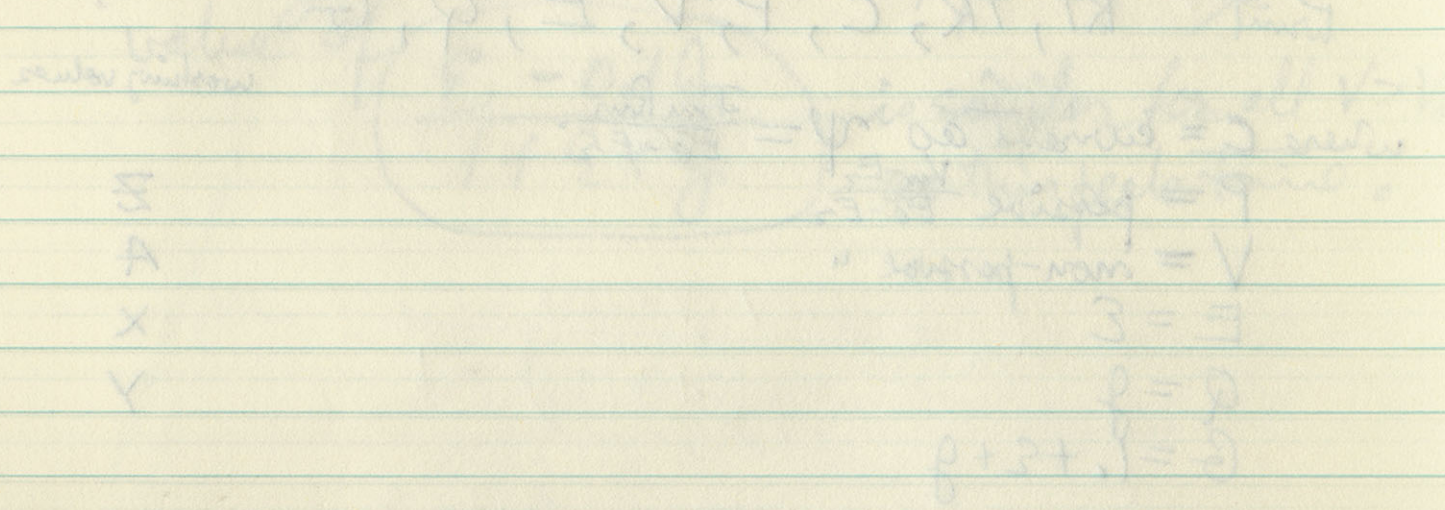
$$\frac{\epsilon - 0.1g}{1 + \epsilon + g}$$

is smaller for all $V > V_h$ as this peak time.

2/25/04 - 2/27/04

Write WXR, YTC

The experiment consists of checking on business account
and about as they are completed. The first part of the
experiment is to check on business account



$KAMP = \begin{cases} +1 & \text{means voltage clamp} \\ 0 & \text{means open circuit} \\ -1 & \text{means non-potential clamp} \end{cases}$
 $KHSD = \begin{cases} 1 & \text{means suppresses V contribution to E} \\ 0 & \text{means no contribution} \end{cases}$

All time approaches $T = 1/c$
 $R(k)$ for $k=1, 2$
 $DX = ERD - ERSS = R(1) + R(2) + R(3) - (R(1) + R(2) + R(3)) * X$
 $DY = GERD - GERS = R(2) + ERSS + R(3) + R(1) - R(2) * Y$
 $DA = C - A + X * (L - A) - Y * (A + 1)$
 $DE = C - E$
 $DC = V - E * (L - V) + D + (V + 1)$

5/28/64

first test of WXR751C

results encouraging: caught error in P

In these tests peak ϵ was ≈ 640
peak γ was ≈ 55 } factor of 10

whereas in H4H, factor is less than 3

Their peak g_{Na} corresponds \approx to $\epsilon = 300$
 g_{K} \approx $\gamma = 120$

This is based on $g_{rest} \approx 0.1$ for their curves.

~~However, their st. state $g_{max} \approx 20 \text{ mS/cm}^2$
for clamp at equilibrium, their $g_{Na} \approx 40 \rightarrow \epsilon \approx 400$
 $g_{K} \approx 20 \rightarrow \gamma \approx 200$~~

Because of this decided to try larger R_5
also add R_7

Next test has two Series

	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1st Series	500.	4×10^4	20.	2.7	0.03	5.	0.
2nd Series	"	"	"	3.	0.1	5.	2.5

6/2/64 2nd Series went too far in this direction.
 Q blew up > 500

2nd Series

		C	Σ	J
.9	.01	-19.7	236	2.9
		<u>>500</u>		<u>>5000</u>
.7	.03	-44.	179	11.3
			227	11.2
				287
.5	.05	-30.	68	5.9
			35.3	11.8
				67.7
.3	.09	-8.8	13.9	1.7
		<u>-1.97</u>		8.11
				8.5

↑
note nearly equal

6/3/64

Analysis of 6/2/64 results with WXR 751C
During Spike

1st Series peak $\epsilon \approx 650$ peak $f \approx 55$
with $f = 15$
at 0.1τ after peak V

2nd Series peak $\epsilon \approx 350$ peak $f \approx 87$
with $f = 20$
at peak of V

Voltage clamping

1st Series

V	TK	C	ϵ	f
.9	peak = .03 final = .9	-43.4 153	523 60	7.9 158
.8	peak .05 final	-71.2 31	257 56	6.5 58
.5	.08	-42.8 <u>-11.4</u>	90 43	3.1 16
.3	.15	-10.8 <u>-8.8</u>	16.3 14	.9 2

become R_7 tends to enhance g_{moss} }
when V is large. } →

∞ New values will be $R_6 = 10.$ (twice previous)
requisite together " $R_5 = 0.1$
 $R_3 = 100.$

Try $R_4 = \{ 1. \text{ and } 100. \}$

Leave R_1 & R_2 unchanged; $R_7 = 0$

Note that $R_4 = 100$ holds E_{ss} to $\frac{g_{ss}}{1 + g_{ss}} < 1$

or more generally, if $R_3 = R_6/R_5$, $E_{ss} = \frac{g_{ss}}{1 + \frac{R_4}{R_3} g_{ss}}$ $\frac{E_{ss}}{g_{ss}} = \frac{1}{1 + \frac{R_4}{R_3} g_{ss}}$

lot steady state.

47

Problem is to decrease E below J for small V & J
Also, second series got J too high.

•• R_7 is really not helpful. Eliminate R_7

Aim to juggle rate constants to reduce E & increase
in spike and in voltage clamp.

↑ to get G fine course correct.

→ Increase R_6 because J decays too slowly

$$J_{ss} = \frac{R_5}{R_6} (R_1 V^2 + R_2 V^4)$$

$$E_{ss} = \frac{R_1 V^2 + R_2 V^4}{R_3 + R_4 J_{ss}} = \frac{(R_6/R_5) J_{ss}}{R_3 + R_4 J_{ss}}$$

•• for J_{ss} very large, $E_{ss} \rightarrow \frac{R_6}{R_4 R_5}$

for J_{ss} very small, $E_{ss} \rightarrow \frac{R_6}{R_3 R_5} J_{ss}$

In order that $E_{ss} < J_{ss}$ for small J_{ss} , need $\frac{R_6}{R_3 R_5} \lesssim 1$

$$\text{for } V=1, J_{ss} = \frac{R_5}{R_6} (R_1 + R_2) \approx 4 \times 10^4 \left(\frac{R_5}{R_6} \right)$$

•• if want J_{ss} around 400, need $\frac{R_5}{R_6} \approx 10^{-2}$

•• need $R_3 \approx 10^2$ to satisfy

R_4 has some freedom: it will effect spike & slope of C_{ss} vs V

for the first part of the problem...

...the second part of the problem...

...the third part of the problem...

...the fourth part of the problem...

$$f_{sc} = f_c \left(\frac{R_1 V^2 + R_2 V^4}{R_1 V^2 + R_2 V^4} \right)$$

$$f_{sc} = \frac{R_1 V^2 + R_2 V^4}{R_1 V^2 + R_2 V^4}$$

for this series: $TK_{3.02}$, $R_2 = 100$ $g^* \approx 300(1-.7) \approx 90$

$$C \approx 0.7 - (0.3)90 \approx -27$$

for second series g^*

Provided that the transients are not ruined, previous pages show that E_{SS} can be held down according to

$$E_{SS} = \frac{\left(\frac{R_6}{R_3 R_5}\right) J_{SS}}{1 + \frac{R_4}{R_3} J_{SS}}$$

in particular, if $R_3 = R_4 = \frac{R_6}{R_5}$, $E_{SS} < 1$

more generally, whatever R_4 may be, if $R_3 = \frac{R_6}{R_5}$, $E_{SS} < J_{SS}$

May possibly need to slow everything down.

If we desire $E_{SS} < \alpha J_{SS}$

then require $\frac{R_6}{R_3 R_5} = \alpha$

look at C for $V = .7$ & see if can estimate peak C.
1st approx would be for $J = 0$ & guessed TK

$$V^2 = .49 \\ V^4 = .25$$

$$E^* \approx (\tau \dot{E})(TK) \approx (TK)(10^4) \quad \text{for } TK = .03, \text{ est. } E \approx 300$$

Better approx is this - $\frac{R_3(TK)(This)}{3}$ i.e. $E^* \approx (TK)(10^4) \left(1 - \frac{R_3 TK}{3}\right)$
e.g. $\approx 300(1 - .2) \approx 240$

for first series. $C \approx V * E^* (1 - V) \approx 0.7 * (0.3) E^* \approx 72 \checkmark$

provided the transformations are not required
previous paper shows that ϵ_{22} can be
held down according to

$$\epsilon_{22} = \frac{\left(\frac{R_1}{R_2}\right) \beta_{22}}{1 + \frac{R_1}{R_2} \beta_{22}}$$

in particular if $R_3 = R_4 = R_2$ & $\epsilon_{22} < 1$

more generally, whatever the number, if $R_3 = R_2$, $\epsilon_{22} > \epsilon_{23}$

that finally need to show everything down

if we desire $\epsilon_{22} < \alpha \beta_{22}$
then require $R_3 = \alpha$

looks at C for $V=0$ & see if our estimate yields C
estimate would be for $f=0$ & desired TK

$$\epsilon_{22} = (C_2)(TK) \approx (TK)(10^4)$$

better approx in this case $(TK)(10^4)$

$$\epsilon_{22} = (TK)(1 - \beta_{22})$$

$$\epsilon_{22} = 300(1 - \beta_{22}) \approx 240$$

$$C \approx V \cdot \epsilon_{22} (1 - \beta_{22}) \approx 0.3 \cdot 240 \approx 72$$

6/4/64 - 6/5/64 Series 3, 4, 5, 6, 7, 8 of WXR751C 49
were run and compared, including also 142

General: In ② spike falls faster than rise (rubbout)
In ③, ⑥, ⑧ fall very similar to rise (rubbout)
In ④ overquenched (rubbout)

①, ⑤ + ⑦ This leaves all look "physiological" because rise is fast & fall is slower than rise

Series ① shows more rounded top, probably because of smallest R_3 and R_5 gave smallest ratio of J_{peak} to E_{peak}

Note that largest ratios of J_{peak} to E_{peak} occurred in series ③ with ratio $> 1/3$

while series ⑧ = $1/3$

& series ⑥ $\approx 1/3$

all these tend to fall too fast.

Comparing ①, ⑤ + ⑦, perhaps ⑤ is prettier, but 741 or OK.

Note that ① corresponds to the extracellular calcs done earlier with WXR 793C

⑦ is similar, but R_6 is doubled, R_3 is 2.5 times

→ This seems to give more realistic J decay rate, but this may have to be tested in terms of refractory period (i.e. blocks & reflections)

6/11/11 - 6/2/11 Series 3, 4, 5, 6, 7, 8 of WXR 731C

were torn and compared, including 103

- in 1) overexposed (inverted)
- in 2, 3, 4, 5, 6, 7, 8 fall corresponds to rise (inverted)
- in 9) spike falls faster than rise (inverted)

The leaves
 all look "physiological" because
 series in part 1 fall in abundance

Series 1 shows more rounded top, probably because of
 smaller R₂ and R₃ give substitution of leaf top

Note that largest ratio of R₂ to R₃ occurs in
 series 3 with ratio > 1/3
 1/3 = 1/3
 1/3 = 1/3
 all three tend to fall too fast.

Series 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100

(P) is similar, but R₂ is smaller, R₃ is 2.5 times
 in abundance, more realistic of decay
 rate, but this may be to be taken in terms
 of independent period (in terms of cycles)

For extracellular study & such applications, need to consider differences of these cases with regard to axon-soma block & synaptic threshold.

For near threshold conditions, there may be a significant difference in the steady J_{ss} which would increase threshold.

ie. just subthreshold, one would reach a ^{near} steady state where $\frac{dE}{dt} = 0 = \frac{dQ}{dt} = 0 = \frac{dV}{dt}$

$$\text{Then } J_{ss} = \frac{R_5}{R_6} (R_1 V^2 + R_2 V^4)$$

$$\text{also } E_{ss} = \frac{R_1 V^2 + R_2 V^4}{R_3 + R_4 J_{ss}} = \frac{(R_6/R_5) J_{ss}}{R_3 + R_4 J_{ss}}$$

For experimental study + such applications, need to consider differences of these cases with respect to over-some block of synaptic threshold.

To reach threshold condition, there may be a significant difference in the steady state voltage across threshold.

in that subthreshold, one would reach approximately

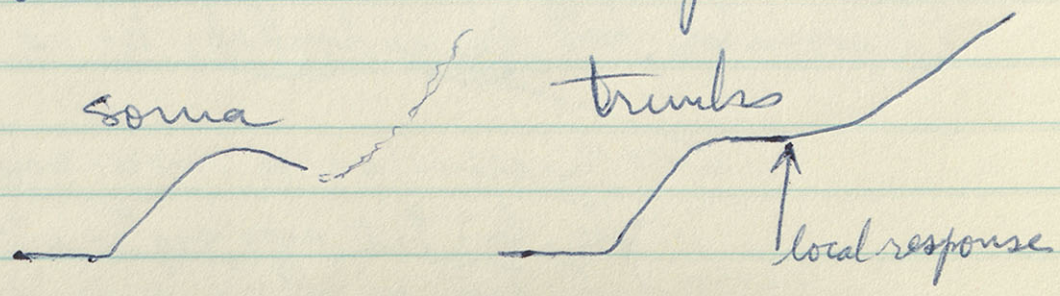
$$\frac{dV}{dt} = 0 = \frac{dI}{dt} = 0 = \frac{dQ}{dt}$$

$$I_{total} = I_{leak} + I_{Na} + I_{K} + I_{Ca}$$

$$\frac{C \frac{dV}{dt}}{R} = \frac{V - E_{leak}}{R} + \frac{V - E_{Na}}{R} + \frac{V - E_{K}}{R} + \frac{V - E_{Ca}}{R}$$

Easiest trick to raise soma threshold is to put a factor such as 0.8 in front of E in the expression for V at the soma

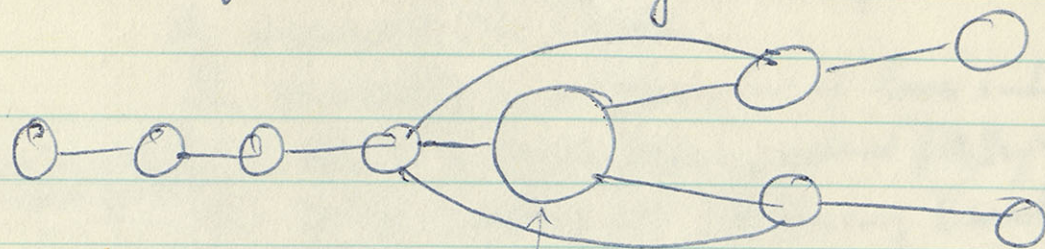
An AB break will occur when the dendritic trunks nearly fail to fire, so that the soma transient starts to decay before the trunks enter local response and takeoff.



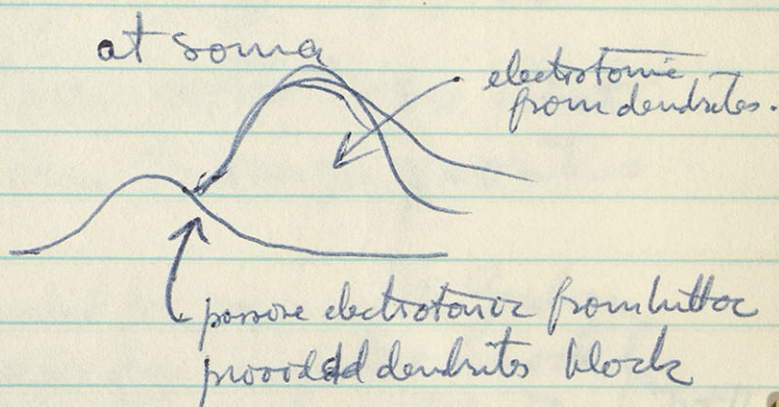
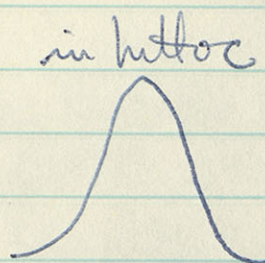
6/6/64

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Thoughts about simulating AB break & block

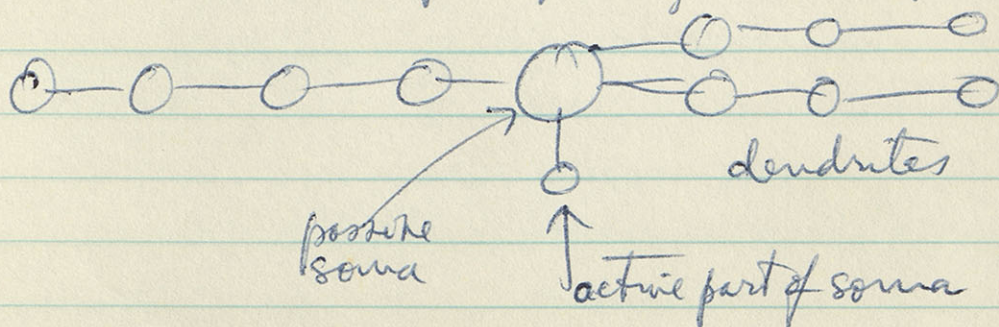


a possible higher threshold passive soma with active dendrites could give A, AB



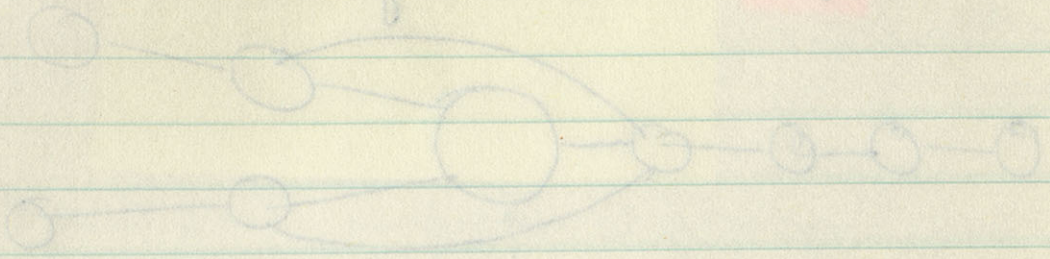
Or possibly, soma need not be passive, provided that it has a higher threshold such that dendrites fire before soma, to give AB break

This could be managed either by having higher soma threshold, or perhaps by dendritic facilitation

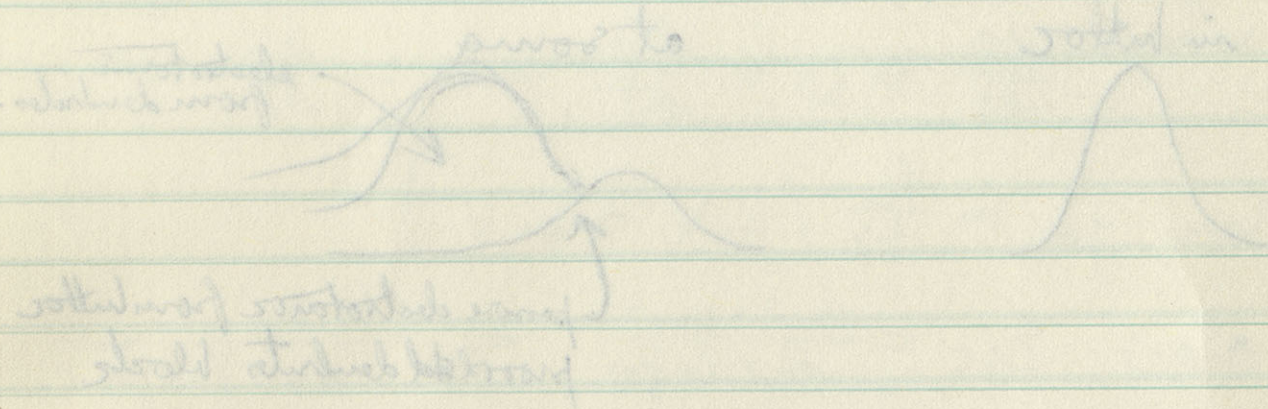


11/1/11

thought about something that's related to blood



with some details could give A, B, a further before that had some sense



On the left side, some text is written, but it is mostly illegible due to blurring and bleed-through. It appears to contain the words 'at some', 'in fact', and 'from within'.

On the right side, there is a large, faint, mirrored image of the diagram from the previous page, which is bleed-through from the reverse side of the paper.

6/10/64 - 8/12/64

52

Major interruption of research

A. one week in Texas

B. one week here taking care of loose ends & thinking about Canberra paper, reviewed Fitzhugh's paper.

also Janowitzman's medical & job situation

C. 3 1/2 weeks at Bethany Beach

D. one week picking up loose ends, reviewing

also garber trees

things for Massan, etc. also cars.

E. one week to complete Canberra paper which was dictated & sent off 8/11/64.

Today looking over old loose notes to see what needs to go in here & also to assign priorities for coming month.

- ① Computations needed for paper with Gordon
- ② Rough out paper on impulse model & check into questions raised by Dick Fitzhugh (see next page for notes from 6/18/64)
- ③ AB break p. 51
- ④ Refer back to p. 34 & p. 5 & p. 30

8/14/64 put pictures up on office wall

- A. ...
- B. ...
- C. ...
- D. ...
- E. ...

Total ...
 ... to ...
 ...

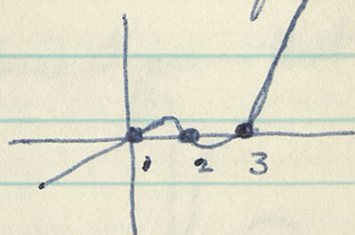
1. ...
2. ...
3. ...
4. ...
5. ...
6. ...

8/12/64 copy of notes dated 6/18/64 after showing
Doch FitzHugh the results of WXR751 (see p. 49)

53

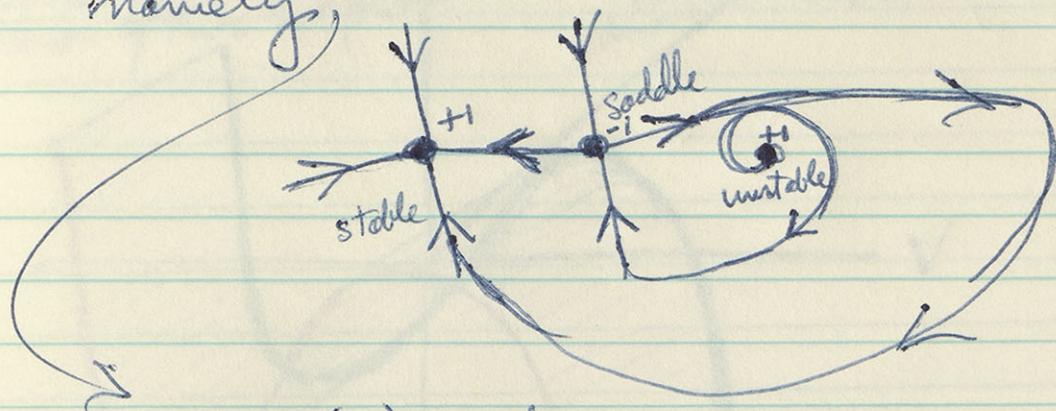
Doch had two suggestions:

- ① Compute E_{ss} and I_{ss} for small V , and then compute and plot I vs V curve to see if there are three singular points, as implied by my crossover point away from origin.



If so, want to investigate stability properties of the third point. It would be awkward if this were stable, because then would have two stable resting potentials.

However, Doch says it could be unstable in a special way which he has not met before, namely,



name a (+1) point where all arrows are directed away

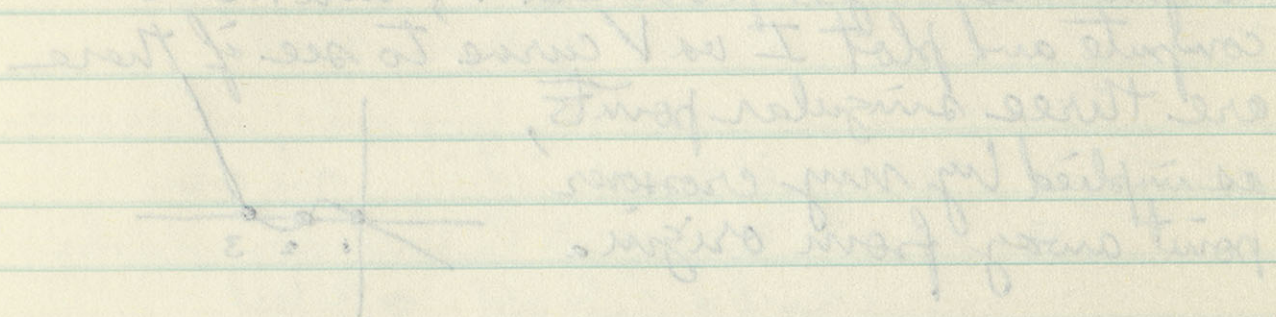
see p. (11.6) of FitzHugh's manuscript appendix

If I really have such a point, he would be quite interested.

8/17/14 copy of notes dated 6/18/14 after discussion
with faculty regarding the stability of WRR 2.21 (copy #1)

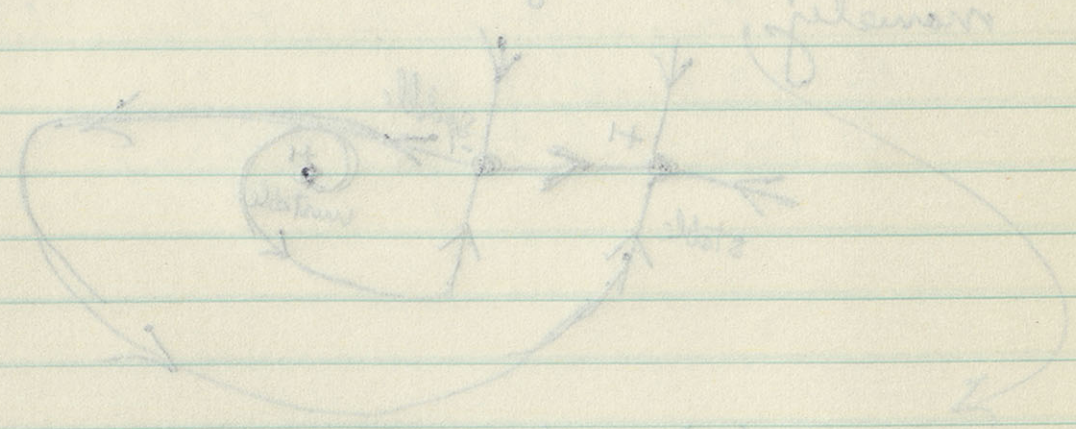
Bob had two suggestions:

(1) Compute E_{ss} and V_{ss} for small V , and then



compute and plot E vs V curves to see if there are three singular points, as implied by my previous point away from origin.
If so, want to investigate stability properties of the third point. It would be unusual if this were stable, because then would have two stable resting potentials.

However, Bob's suggestion could be unstable in a special way which we had not met before

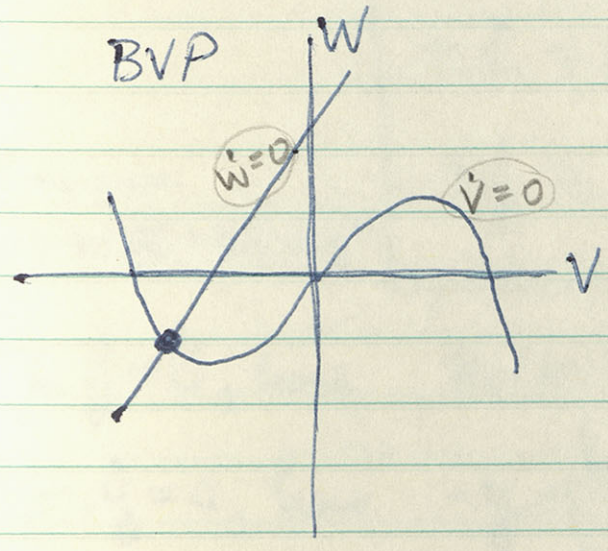


near a (+) point where all errors are damped away
See p. 11.6 of the book's appendix

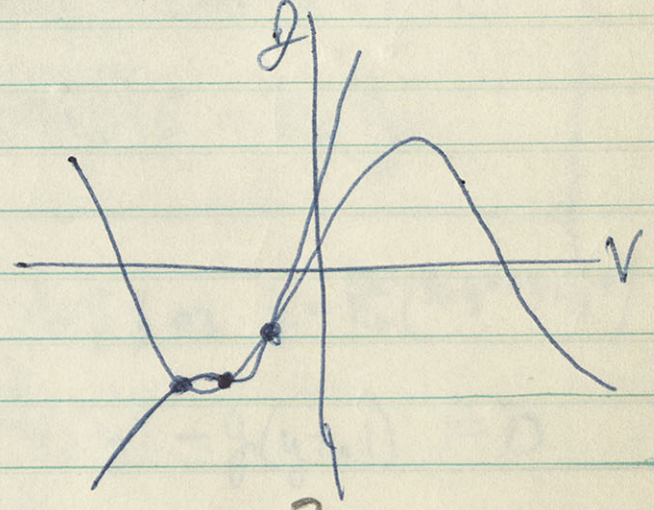
If trajectory has such a point, it would be quite interesting.

also, plot $\begin{matrix} g \\ \vdots \\ \hline \vdots \\ v \end{matrix}$

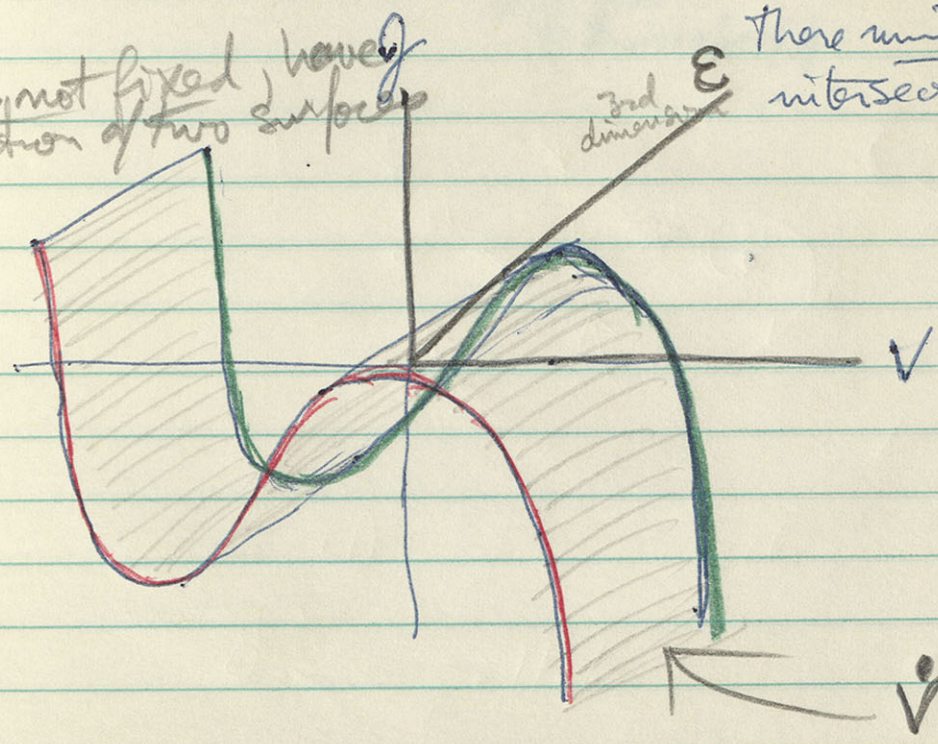
for E constant at st. st. value, to get nearest approx to BVP model.



Here it seems that



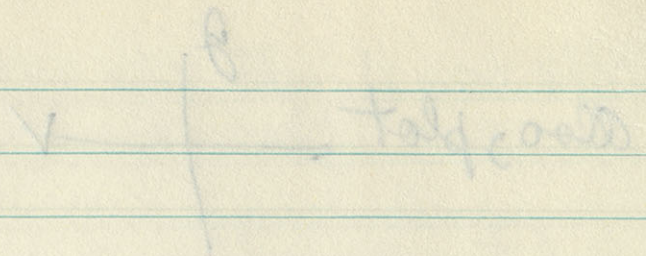
For E not fixed, have 3 intersection of two surfaces



3rd dimension E

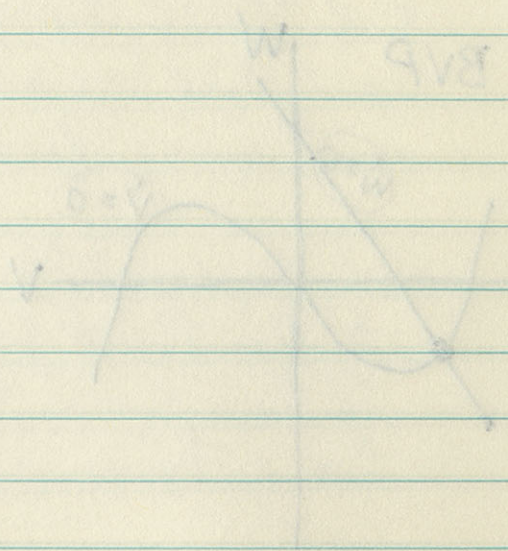
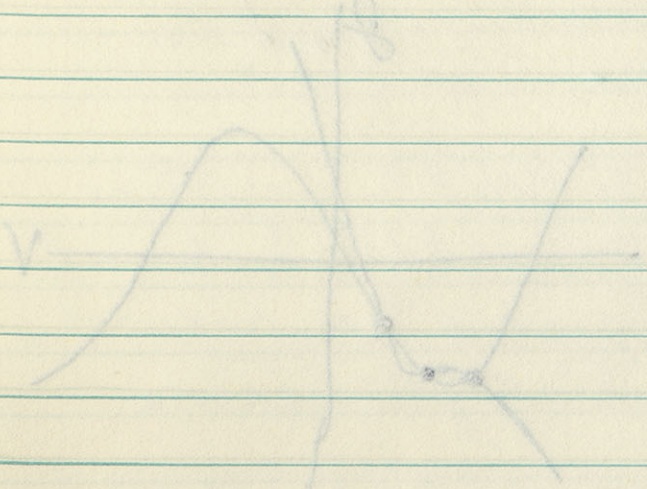
There must be three intersections here also.

Intersects with surface, $\dot{g}=0$

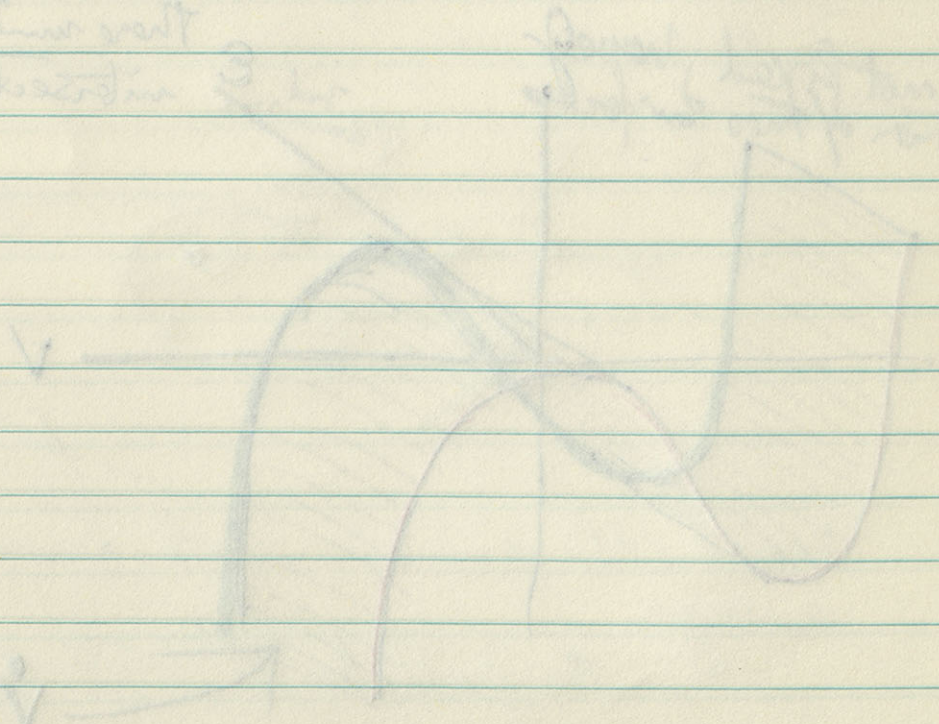


for constant of st. value, to get nearest
 approach to BVP model.

There is a constant



There are three
 intersection lines



$v=0$

$p=0$

Intersection with axes

55

Refer back to page 35 of this book, where $y = \frac{V_m - E_r}{E_c - E_r}$

Also, set $\psi = 0$ and $\beta = -0.1$

Then

$$\dot{y} = -y + \varepsilon(1-y) - f(y+0.1)$$

$$\dot{\varepsilon} = k_1 y^2 + k_2 y^4 - (k_3 + k_4 f) \varepsilon$$

$$\dot{f} = k_5 (k_3 + k_4 f) \varepsilon - k_6 f$$

$\dot{\varepsilon} = 0$ gives

$$(k_3 + k_4 f) \varepsilon = k_1 y^2 + k_2 y^4$$

for $\dot{f} = 0$, have $k_5 (k_3 + k_4 f) \varepsilon = k_6 f$; or $f = \frac{k_5}{k_6} (k_1 y^2 + k_2 y^4)$

for $\dot{y} = 0$, have $-y + \underbrace{\left(\frac{k_1 y^2 + k_2 y^4}{k_3 + k_4 f} \right)}_{\text{st. st. value of } \varepsilon, \text{ as a fn of } f} (1-y) - f(y+0.1) = 0$

Refer back to page 32 of this book, where $f = \frac{1+\mu}{1-\mu}$

also, set $\mu = 0$ and $\beta = 0.1$

$$\begin{aligned}
(1+\mu)\beta - (\mu-1)\beta + \mu - \mu &= \beta^2 \\
\beta(1+\mu) - \beta(\mu-1) + \mu - \mu &= \beta^2 \\
\beta(1+\mu) - \beta(\mu-1) &= \beta^2 \\
\beta(1+\mu - \mu + 1) &= \beta^2 \\
\beta(2) &= \beta^2 \\
2\beta &= \beta^2
\end{aligned}$$

then

$\beta = 0$ or $\beta = 2$

if $\beta = 0$, then $\beta(2) = \beta^2 \Rightarrow 0 = 0$ or $\beta = \frac{\beta^2}{2}$

$$0 = (1+\mu)\beta - (\mu-1)\beta + \mu - \mu$$

$\frac{1+\mu}{1-\mu}$
 or $\beta = 2$

8/22/64 Got Dorothy to run off old dittos
of Spherical Neuron Field paper
& preparation to completion of same.

56

8/24/64 Discussed late potential of Olfactory
Bulb field potentials with Gordon
today. (See next page)
We had plotted the theoretical
iso contours (vs depth & time) on Friday.
Now, analyzing to see what ought to be
checked out next.

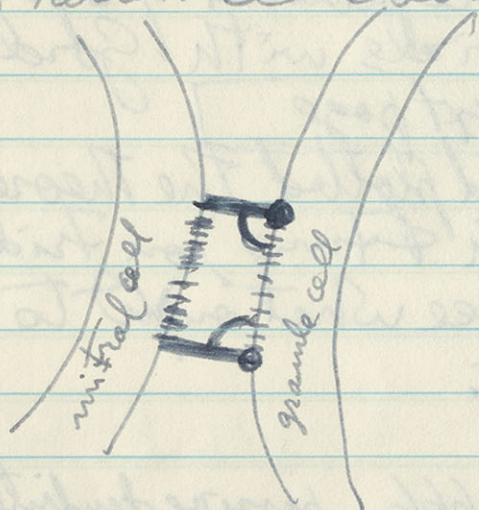
The ones plotted were 64791.0666 passive dendrites (hot kinetics)
and 64791.0669 active dendrites (cool kinetics)

Question was raised whether secondary dendrites should
be treated separately because of

- (a) they contribute differently to extracellular pot
because λ vs depth is different, even
for antidromic. This may smear
after positivity, even for active dendrites.
- (b) possibility of different synaptic activity

I

The resting state of plaque could be like a low resistance electrical synapse.



The hatched membrane has high conductance, e.g. high K^+ permeability from one cell to the other, in both directions.

For mitral cell depol. to have depol. effect on granule cell, e.g. K^+ would flow from m. to g.

II

Sufficient summation or regeneration of ~~mitra~~ granule cell depolarization causes a change which exposes the mitral cell K^+ plaque to the extracellular medium, causing inhibition.



As though hinged gates have swung from mitral contact to granule contact.

In effect, this would prevent K^+ back flow from g. to m. & lock m. near rest.

8/24/64

Thoughts about dendro-dendritic synapses between granule cells & mitral cells of olfactory bulb.

- ① The late potential is a dipole with zero contour at mitral soma layer, neg peak in external plexiform layer & pos. peak in internal plexiform layer. Seems to best fit granule cells, because I feel that such a symmetric dipole depends upon a substantial core conductor which extends from the neg. to pos. peak. also
- ② This epoch is associated with mitral cell inhibition. \therefore the other, but remoter possibility is an active hyperpol. being caused at mitral axon hillocks

Here is a model whereby dendro-dendritic contacts between mitral cells and granule cells could account for these phenomena.

Formally, activation of the mitral cell (either anti- or orthodromic) will depolarize its secondary dendrites; these could, by dendro-dendritic plaques, depolarize the granule cell dendrites; if the granule cell depolarization reaches some threshold, then the plaques change to have

perhaps due to regenerative depolarization
 an inhibitory effect upon the mitral cells. \rightarrow The regenerative depolarization of the granule cells would set up the prolonged dipole field that is recorded.

The granule cell has no axon \therefore may have no prop. spike.

This inhibition would form a "lateral" or "surround" inhibition and should serve to sharpen contrast.

or
collaterals
could be
this

For #5 of p. 49

cf. page 35 ↓

$$R_1 = 500$$

$$R_2 = 4 \times 10^4$$

$$R_3 = 50$$

$$R_4 = 1.$$

$$R_5 = .05$$

$$R_6 = 10.$$

$$R_{ACT} = 500$$

$$R_{BSQ} = 1. ; R_{BFR} = 80.$$

$$R_{OUTB} = 50.$$

$$R_{OUTC} = 10$$

$$Q_{ENCH A} = R_5 * R_{ACT} = \frac{500}{20} = 25$$

$$Q_{ENCH B} = R_4 * Q_{ENCH A} = 25$$

Try	Cool	Hot
R _{ACT}	400.	600.
R _{BSQ}	1.	1.
R _{BFR}	80.	80.
Q _{ENCH A}	20.	30.
R _{OUTB}	50.	50.
R _{OUTC}	10.	10.
Q _{ENCH B}	20.	30.
APPOS.	10.	10.

8/25/64 Because 64791.0666 (passive dendrites) (hot kinetics) 58

used dendritic ϵ in order to avoid delayed or blocked soma spike, it is not possible to run the equivalent problem for active dendrites. Geometric handicap: $\frac{USD}{USA} = 80.$

∴ Decided to try to reduce geometric handicap to a value of 40. and try to manage without dendritic ϵ .

Also, now using WXR793C (although 791 still avail) and consider that $\dot{V} \propto RBSQ * V^2 + RBFR * V^4 + \dots$ whereas in WXR791C we have $\dot{V} \propto RINB * V^3$

∴ Set up 64793.8100 series for new cool kinetics with $L/a = .8$
and 64793.8800 series for new hot kinetics with $L/a = .4$

	UA	UD	USA	USD	$\frac{USD}{USA}$	DZ
for 8100 series	25.	100.	2.	80.	8	.1
for 8800 series	100.	400.	2.	80.	8	.05

Here the UD values = $\left(\frac{1}{DZ}\right)^2$, as they should
 $UA = \frac{1}{4} UD$ to take care of diameter for some ΔL

9/25/04 Because 64771.0000 (passive banknotes) (hot banknotes)

used banknote 3 million to avoid illegal
of bank some notes it is not possible
to print the equivalent problem for
active banknotes. $0.8 = \frac{0.2}{0.25} = 80\%$

∴ needed to try to reduce government banknotes
a value of 100, and try to manage without
banknote 3.

~~53 ago exp 10 1/2 1/2 1/2 1/2~~
Also, new unit WKR 73C (about 71 250 each)
and number that 5-0-RES 4-2 + RBR 2-15 = 11...
R = 50 ROOTB = 50

∴ Set up 64771.8100 series for new cool banknote
with 1/4 = 0.25
R = 50

Set up 64771.8800 series for new hot banknote
with 1/4 = 0.25
 $52 = \frac{20}{0.38} = 105.26 = 105.26$
 $22 = \frac{100}{4.5} = 22.22 = 22.22$

USD	100.00	100.00	100.00
USD	80.00	80.00	80.00
USD	20.00	20.00	20.00
USD	10.00	10.00	10.00
USD	5.00	5.00	5.00
USD	2.00	2.00	2.00
USD	1.00	1.00	1.00

8/26/64

59

64793.8101

axonal spike fine: blocked at soma $\neq 0$.
(active & passive very close)

dendritic I.C.

64793.8102

"

again

.05

This consumed check out 5 minutes. $IPAB = 0$

$NT * NSTEP = 404$

8/27/64

cool kinetics, dendritic I.C. = 0.1

64793.8103

soma block with passive dendrites
barely above threshold with active dendrite

64793.8801 - 8804 all blew up because NSTEP was
too small for hot kinetics

64793.8104

I.C. = 0.15

soma block with passive dendrites
soma invaded with active dendrites
axon had a reflected orthodromic,
presumably because of soma delay.

peak = 0.1590

64793.8105

I.C. = 0.2

soma block with passive dendrites
soma invaded with less delay (active dendrites)
in this case there is no reflection in axon.

peak = 0.2113

synchronous
soma-dendritic \rightarrow

64793.8805

did not have an axonal spike.

These kinetics (hot) were presumably ~~overgrounded~~

also

64793.8811

8/28/64 Due to $VA = 100$ implying $\Delta Z_A = 0.1$

Example of Rucklitz's critical length requirement

8/22/04

29

PT 193.8101
open spine fine & label of same ≈ 0.1
(extra female spines)

PT 193.8102
" " again ≈ 0.2

The common chestnut 5 minutes. $193 = 0$
 $NT * 193 = 404$

8/22/04
PT 193.8103
some look with female spines
heavily above threshold with extra spines

PT 193.8801 - 8804 all blew up because 193 = 0
too small for label

PT 193.8104
 $2.C. = 0.12$
some look with female spines
some mixed with extra spines
open had a reflected or broken
presumably because of some delay.
 $193 = 0.113$

PT 193.8105
 $2.C. = 0.2$
some look with female spines
none mixed with extra spines
within case there is no reflection in case.

PT 193.8805
did not have an open spine
The 193 (193) was $193 = 0.1$
 $193 = 0.1$
number of spines with female spines

8/28/64

60

64793.8812 UA still 100. implying $\Delta Z_a = 0.1$
I.C. = 0.4 in ① and ②
even so, axon still failed to fire.

64793.8813 same with I.C. = 0.8 in ① only.
Here axon did fire, but soma blocked.
even though dendritic I.C. = 0.05

Now reduce UA = 50., VD = 200. $\frac{USD}{USA} = 40$
DZ = 0.0707

RACT = 600.

QA = QB = 30.

Also Giant Extracellulars

64793.8814 dendritic I.C. = 0.1
got long axon - soma delay
beginning of synchronous
dendritic spike

64793.8815 dendritic I.C. = 0.2 axon soma delay
.07C

Good Soma spike, except possibly
falls too fast, may wish to reduce quench

*

Dendritic Spike synchronous
good when wish to show how
this reduces extracellular.

Good Giant Spike $\left\{ \begin{array}{l} \beta = 100, 25 \\ \gamma = 1, 1 \end{array} \right.$

PHYS. 8812 UA 100.0 mV $\Delta V_a = 0.1$

I.C. = 0.4 in ① and ②

same, even still failed to fire.

PHYS. 8813 same with I.C. = 0.8 in ① only

Here, even did fire, but some blocked.

even though shorter I.C. = 0.02

PHYS. 8814 UA = 50.0, VD = 200.0, $\frac{V_D}{V_A} = 40$

DF = 0.0707

PACT = 600.

QA = QB = 30.

Class Joint synchronous

PHYS. 8814

debit I.C. = 0.1

got long wave - some delay

beginning of synchronous

debit spike

PHYS. 8812

debit I.C. = 0.2

PHYS. 8812

~~Good some spike, next month
falls too fast, need to adjust~~

debit spike synchronous
and some work to do later

this is a joint synchronous

Good some spike, $\rho = 100, \sigma = 25$
 $\rho = 1, \sigma = 1$

8/27/64 - 8/28/64

VA=25.
UD=100.

$\frac{USD}{USA} = 40.$

61

64793.8104 Cool (RACT=400. Quench=20.)
Dendritic I.C. = 0.15 IFAB=0

got delayed soma spike for active case (quench reflection)
" blocked " passive

64793.8105 Dendritic I.C. = 0.2

Active Dendrites fired 0.02% ahead of soma; almost synchronous

Soma blocked in case of passive dendrites,
although soma peak = 0.2113
must be near threshold.

64793.8201 Dendritic Synaptic E

also $\frac{USD}{USA} = \frac{1}{4}$ to make axon mimic load
USD=UD due to secondary dendrites of mitral cell

Discovered ^{program} problem of some undefined dendritic J.
This difficulty removed by WXR 794C

* Successfully caused soma to fire in spite of secondary dendritic load. Soma ~~spike~~ ^{secondary} spike was synchronous
but note that secondaries active like soma

* Sharp falling phase of ^{soma} spike is responsible for pos. peak of extracellular
RACT=400. Quench=20.

Note: for extracellular potentials of population. May need to compute some spatial and temporal smear.

also, firing & non firing smears

May need to invoke radial V_e to get deep pos. but I believe it can be gotten also by placing E farther out in dendrites.

8/28/64 - 8/29/64

62

64793.8202 similar to 8201, except only 6 dendritic cpts.

Put $E = 8.$ in two most peripheral cpts.
Put $g = 8.$ in two trunk cpts.

Soma and secondaries fired at very end, after the inhibition had been turned off.

At peak of dendritic E_{sp} (i.e. $KT = 40$), for $KVE = 2$
(i.e. strut
external)

Get Neg V_e in cpts 9 & 10
pos V_e for the rest.

(But this is not a ^{yet} good model for granule cell because of the heavy axonal (2ndary dendritic) load)

64793.8203 $VA = UD = USA = USD = 25.$

This is granule cell equivalent cylinders
~~Put~~ Put $E = 1.0$ in dendritic trunks (5 & 6)
also $R_{ACT} = 100.$ and $g_{rench} = 10.$

passive synaptic potential starts out spatially symmetric
However, asymmetry develops, presumably, because of local response in ~~axons~~
compartments 1-4.

for $KVE = 1$, all cpts are neg. except cpt. 10 at zero
for $KVE = 2$, cpts 5 & 6 most neg.; cpt 10 most slightly +

For granule cell, need deep source, ~~rather~~ to make deep pos.

047M3.8202 \rightarrow similar to 8201, except only 1 substrate site

to substrate \rightarrow substrate \rightarrow substrate

same but occurrences first at very end after the initiation had been turned off.

near 047M3.8203 \rightarrow 3pp (in KT=10), for KVE=2

got 1/2 in 10 04/10
got 1/2 for the rest

047M3.8203 \rightarrow UA=UD=USA=USD=22

This is equivalent cell equivalent values
Part 3 = 1.0 in substrate tanks (580)
also RACT = 100. of punch = 10.

because of local properties in \rightarrow
competition 1-11

all the one was off 10 at zero
for KVE=1, for KVE=2, for KVE=3

8/31/64 WXR794C

63

revision of WXR 793C

Increased dimensions of BEB (JZ, KEJ) to (14, 10)
and BJC (JZ, KEJ)

and arranged to read in from separate cards 966 format
which include all compartments for E & J at 2453

Also, ~~at~~ ^{after} 382 $AB(JZ) = AB(JZ) + BEB(JZ, KEJ)$

9/1/64 connected this ^{to loop 384} $AC(JZ) = AC(JZ) + BJC(JZ, KEJ)$
~~at~~ 380

This means that E & J are added to existing values
at KTA, and nothing is done at KTB in
the active case, whereas E & J are set
to zero in the passive case, ~~but not~~ in
the axon and soma.

at 725 arranged a test such that

IFVE = 1 skips printing out case of KVE = 1
and goes directly to KVE = 2.

whereas IFVE = 2 or greater gives $\left\{ \begin{array}{l} KVE = 1 \\ \text{and } KVE = 2 \end{array} \right.$

i.e. only with external shunt.

Note: to mimic radial effect on deep re, could make
CORE > 1.

version of WXR 793C

General description of BEE (25, KE2) and R2C (25, KE2) P(11/10)

and enough to read in from separate cards. P(11/10) and include all components for 3 + 2 rows

AR(15) = AR(15) + AR(15) + AR(15) KE2
AC(15) = AC(15) + AC(15) + AC(15) KE2

This means that 3 + 2 are added together when at KTA and other things done at KTR in the other case, because 3 + 2 are not to go in the paper case, but in the other all same.

WXR enough a to read that

LEVEL = 1 chips printing out and KVE = 1
and printing KVE = 2

LEVEL = 2 or greater great KVE = 1
and KVE = 2

is only in the external about.

to the minor which affect on help as, could make
KVE > 1

8/31/64

64

64793.8816 dendritic I.C. = .2, .2, .15, .10, .05, .0

otherwise like 8815 on p. 60

Here attempted make ~~some~~ dendritic spikes less synchronous.

got long axon-soma delay $\approx .25 \tau$
and it looks as though dendrites would be synch.

64793.8817 Reduced quench from 30. to 20.
and ROUTB from 50. to 40.

Also added a third giant. $\beta = 6.2$

↑ moved too large for Gordon

dendritic I.C. = .25, .20, .15, .10, .05, .0

axon-soma delay $\approx 0.18 \tau$ & got reflected ortho.
dendritic spike almost synchronous.

64793.8818 Same except I.C. = .25 in all dendritic cpts.

obviously underquenched.

8817 had interesting spike shape, but probably fell too slow.

better in 8819 where quench was increased back up to 25. (see next page)

61772.8816 *habitus* I.C. = 2.2, 1.2, 1.0, 0.2, 0

attenuata 8812 or 8810

How it looks on the ground
specimens.

got very open - some delay in 2.2

and it looks on the ground but into wood

Reduced growth from 2.0 to 2.0

and 1.0 to 1.0 from 2.0 to 1.0

also added a third plant. 8-6-02

top and too long

habitus I.C. = 2.2, 1.2, 1.0, 0.2, 0

open - some delay in 0.85 got reflected

habitus spikes almost *apiculata*

61772.8818 same as 8812 I.C. = 2.2 in all *habitus* etc.

obviously underrepresented.

8817 but interesting spike shape, but probably fall
too dense.

later in 8817 when growth was increased

heads up to 2.2. (see next page)

9/1/64

64793.8819

65

quench = 25,

ROOTB = 40.

dendritic I.C. = .30, .30, .20, .20, .10, .10

IFAB = 0

Good run: { axon soma delay = .07 τ
for active dendrites } synchronous dendritic spike

Shape of action potential very good

for passive dendrite: axon soma delay = .19 τ
reflects orthodromic

Good giant extracellulars

This series has shown that for active dendrites $6x(\Delta Z = .071)$
 $Z \approx .42$

it is almost impossible to avoid synchronous dendritic

~~spike.~~

if this wipes out extracellular (must now be run)
this may provide a strong argument against
active dendrites, contingent upon Z length.

Note that 64791.0669 had $Z = 5x(.25) = 1.25$

Also, AB story may need somatic inhibition and perhaps USA
larger. Note that soma has disadvantage rel. to active dendrites
because it is yanked down by hillock after pos. Maybe hillock should be cooler.

1/1/10

PM 12.8817

quadr = 22

roots = 40

initial F.C. = .30, .20, .20, .20, .10, .10

TF88 = 0

Good man: }
~~Good man~~ }
aggressive behavior

0.75

Shape of action potential up good

for poor behavior: aggressive delay = 0.15
reflected outwards

Good guy out of cellular

the neuron has a threshold for action potentials (x/12 = 0.11)

x = 0.12

it is almost impossible to avoid spontaneous behavior

off the neuron out of cellular (used now in year)

there are many other a strong argument against
action potentials, continuous upon x length

Note that (4/11/01) but x = 0.12 = 1.22

As the neuron is a simple machine and neuron 12A

the cell that is the neuron of the neuron is a

9/1/64

66

64794.8204 first test of new program.
mimic granule cell.

Result everywhere zero.
(program fault at statement 380)

64794.8205 had same trouble & led to
discovery of problem

Now put in a recompile

Reran 64794.8205 started but blew up because
 $NSTEP = 10$ too small for $DT = .05$

Put back as .8206 with $NSTEP = 20$

64793.8820 worked very well
quench = 25. $ROUTC = 40$.
 $I.C. = 0.3$ at soma & dendritic tufts

Both Active & Passive were good.
Except active had too little axon soma delay

Set up Production runs (9/3/64) $NT = 51$, $DZ = .1$, $NJD = 8$, $NJG = 2$

.8821	similar to 8820 with $IPAB = +1$	<i>actually not consistent with $UD = 200$.</i>
.8822 8819 -1	
	initial conditions	

Continued on p. 74

4/1/74

CH774.8204 first lot of open program,
numeric program cell.

CH774.8205
program for the station
200

CH774.8205 had some for the station
recovery of program

Was put in a separate

CH774.8202 started but then up because
WSTEP = 10 too small DT = .02

CH774.8202 with WSTEP = 20

CH773.8820 worked very well
ground - .02. ROOTC = 40.
I.C. = 0.3 of some of white time

Both direct lines were good.
Graph active but too little response delay

CH773.8820 similar to 8820 with WSTEP = 10
- - - - -
CH773.8820
initialization

↑
initialization
WSTEP = 10

Control on p. 14

9/2/64 - 9/3/64

67

64794.8206 attempt at granule cell with all $\mu = 25$.

Results suggestive, but $DT = .05$ too large
also $R_{ACT} = 200$. too large
for $\epsilon = 4$.
got pseudospike at $KT = 2$

So set up 8207 with $DT = .02$, $NSTEP = 10$
deleted I.C.
reduced R_{ACT} to 100.
also R_{OUTB} to 10.
and R_{OUTC} to 5.
& ϵ (dendritic) to 2.
 J to 1.

64794.8207

↗ this was still too hot & too fast in
the dendrites

However the polarity of
the extracellular works out pretty
well as we want it.

de. periph neg ≈ -2.0 mV
central pos $\approx +2.0$ mV

set up 8208 with $R_{ACT} = 10$.

quenches = 2.

$R_{OUTS} = 2$.

and add $\epsilon = 2$. to most peripheral dendritic
opt. also.

Next on p. 72

Stefanis thinks that normally, many cells do not invade antidromically. The invasion can be induced by depolarization, either by a drug, or by penetration with an intracellular electrode.

However, GABA + Glutamate presumably provided inhibition, locking soma & providing a bigger gradient from soma to dendrites, esp when the dendrites fire. This gives larger current and larger \oplus peak. If the final \ominus is very large, this could mean soma fires late, ~~if~~ (presumably skipped before when initial neg. was caused by hbtoc)

9/3/64

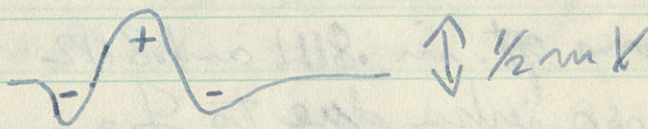
68

Talked with Stefanis (St. Elizabeths)
& Gordon

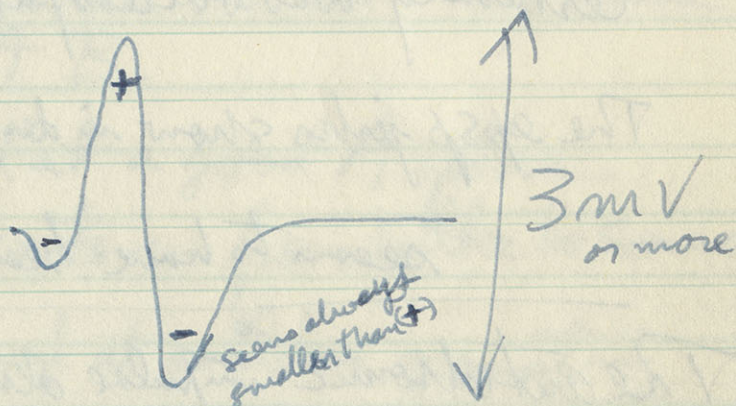
He records extracellularly from Betz cells,
with & without drugs. He also has good intracellular records.
for antidromic, there is a small + due to approaching impulse
nominal extracellular



glutamate increases
rate of spontaneous firing.
(he says it depolarizes the cell)
depresses amplitude of extracellular



GABA alone stops cell
but GABA + glutamate
gives extra large
extracellular



My tentative interpretation: initial negativity caused by some firing.
(as in 1962 Bishop J.)

middle pos, if small, could be due to repol. of soma.
if large, presumed also due to dendritic firing.
& then last neg. due to dendritic repol.

~~largest~~ glutamate depol. perhaps whole cell, but esp. dendrites.
and this favors dendritic firing & hence enhances
the middle (+) and final (-)

9/4/64 Results.

The inhibitory J was too strong (also the E)

(probably due to $AB \neq AC$ being in different units from E & J)

seep. 93 of Book 3

Here $\Delta B = .2$

$\Delta C = 2.$

$$E \rightarrow B * RACT = 400 * B$$

$$J \rightarrow C * QENCHA = 20 * C$$

Soma opt. in .8111 and .8112 clearly shows ~~the~~ severe ipsp jerks due to J .

Certainly was successful in preventing soma firing.

The epsp jerks show in dendritic periphery for $KT=5$
at $KT=15$

seems to have been refractory at $KT=10$ and $KT=20$

The antidromic impulse almost succeeded, but inhibition was too severe.

reduce ΔB to 0.1 } for .8114-8116
 ΔC to 0.5 }

9/3/64

69

Setup 64794, 8111, .8112, .8113

which carry on from 64793, 8104 & 8105

with a new emphasis Cool kinetics

The hope is that F.C. & dendritic E alone (.8113) will cause spontaneous firing.

That this plus soma trunk J will not (.8112)

& that both, plus antidromic, will fire first in the dendrites and then in the soma, thus giving a somatic AB.

$\frac{USA}{UA} = \frac{10}{25}$ aimed at a good A sphere
electotones from luteal to soma

$\frac{USD}{USA} = \frac{100}{10}$ aimed at milder geometry

Four NEJ aimed at sustaining the E & J for a longer time.

May wish to spot check this for one case.

See p. 82

Gordon likes $\frac{USD}{USA} = 40$. intuitively, in preference to 80.

setup 64791. ~~6~~9601 as new variant of 0666 perhaps should use 33.
with $NID = 5$ and $DZ = 0.1$; $UD = 100$ $UA = 25$.

if some capacity is 2.5 times that of axonal cft., get $USA = 10$,
and $USD = 400$.

implying that some capacity is half that of combined
dendritic first compartments.

9/4/64

70

Looking back at 64791.0666
 .0669

To weigh suitability for paper, or how
 could be improved. Zero hour approaches,
 for writing the paper with Gordon.

In these two, we had $CORE = .02$ and $\frac{USD}{USA} = 80$.

also dendritic $Z = 0.625$ in .0666

$\rightarrow Z = 1.25$ in .0669

Probably too long.

Our latest review of Mitral Cells suggests the
 range 0.5 to 1.0 or 0.4 to 0.8
 as closer

Soma

Also, here Threshold was close to 0.1

Whereas in current 64794.8800 series it seems to be around 0.25

- * Could check & characterize by threshold synaptic pot.
- * Could do series to test threshold at soma and dendrites.

In both 666 and 669 axon-soma delay was
 probably too large. (not sure really, except that
 there was reflected spike in 669)

* Reconsider $CORE$ and $\frac{USD}{USA}$ ratios

Suppose $\frac{DD}{DA} = 3$, then $\frac{USD}{USA} = 5 \times (3)^2 = 45 \approx 40$

or suppose $\frac{DD}{DA} = 4$ for primaries
 and 2.5 for four secondaries get $16 + 4(6.25) = 41$

Whereas $CORE$ depends upon $\Sigma d^{3/2}$ and get $\approx (8 + 4 \times 4)^{-1} \approx \frac{1}{24} \approx .04$

looking forward to 4/14/04
0.000

To write something for paper, or have
could be improved. The main objectives
for writing the paper with Jordan.

And as two, we had $CORF = 0.2$ and $USA = 80$.

also distribute $F = 0.622$ in 2000

$F = 1.22$ in 2000

Probably too large
The latest version of Michael also suggests the
range 0.2 to 1.0 or 0.4 to 0.8
as class

Notes

class, we threshold was close to 0.1

When in current 4/14/04 8000 series it was to be used 0.25

- * Could be a series to test threshold at some in distribution
- * Could be a series to characterize by threshold significant.

... probably too large. (not sure really, but that
... of training in the ...

... $USA = 10$... $CORF = 80$...

... $USA = 10$... $CORF = 80$...

... $USA = 10$... $CORF = 80$...

... $USA = 10$... $CORF = 80$...

9/11/64

Try to catch up.

21

Have gotten snowed under this week, between doing many calculations & talking with Gordon about the write up, figures, terminology, etc.

Current Calculations are in ~~three~~⁵ series

Series 64794.8800 antidromic, hot kinetics, active & passive varied USD and NTD and I.C.

Series 64794.8100 ^{antidromic} cooler kinetics \rightarrow ^{the later} Stefania problem
p. 82

Series 64794.8200 granule cell problem ^(at first, just dendritic S.P. with secondary load)

Series 64791.9600 modification of 64791.0666 Passive
64791.9900 " " 64791.0669 Active

11/10/04

Time to catch up

11

Have gotten several under this week, between doing many calculations & talking with people about the waste up, figured terminology, etc.

Using calculator one in the series

Series 64 114.800 arithmetic, latitudes, rates & forces
varied USD and USD and I.C.

Series 64 114.8100 arithmetic → system problem

Series 64 114.8200 general cell problem

Series 64 114.1500 modification of 64 114.0000
64 114.1700 " " " " " "

9/11/64

64794.8200 Series

72

Granule cell extracellular Potential Model
Began p. 67 where have 64794.8206 & 8207

64794.8208 Here $RACT=10$. ; $ROOT \& QENCH = 2$.
use $B=2$ in most periph cpts. also.
Interesting but cpts 1, 2, 3 & 4 fired in 2nd phase
(not wanted)
also cpt. 12 action pot. as large as 9010

∴ Decided to increase B in cpts 8
decrease B in cpts 10, 11, 12
& put long sustained C into 1, 2, 3...

64794.8209 suppression of spike in 1, 2, 3 & 4 worked.
But got spike later cts in 10, 11 & 12
Also peripheral sink relatively too strong
 $V_e = 1.8$ at later peak
 $V_e = -1.6$ at peak

∴ Added stronger inhib. to cp. 7 & 10, 11, 12.

64794.8210 Worked quite well with regard to synchrony
of deep + & superficial - extracell.
However, neg was too large rel to pos.
∴ ~~added~~ added C to cpt. 8 to
weaken sink & shift crossover

64794.8211 This worked rather well. Note the potential scale
is arbitrary. Here
also τ is a free parameter used factor of 3 in plots

9/11/64

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64794.8200 Series
granular cell extracellular potential Model
Bogom p. 67 also have 64794.8206 & 8207

64794.8208 New RACT=10; RMT & GEMT = 2.
use B=2 in most graphs of also
interesting but cpts 1, 2, 3 & 4 find in all places
(not wanted)
also cpt. 12. not graph, as larger 2010

to be added to answer B in cpts 8
answer B in cpts 10, 11, 12
of first long section C into 1, 2, 3...

64794.8209
suppression of spikes in 1, 2, 3, 4
worked.
Back got spikes later on in 10, 11, 12
also peripheral sink related to cpts
ve = 1.8 g
ve = 1.6
2 g

is added storage into cpts 7 & 10, 11, 12

64794.8210
Worked quite well with regard to suppression
of dip + suppression - extracellular.
However, response too large and too fast.
is added storage into cpts 8 to
independent & shift responses

64794.8211
This worked rather well
also in a few minutes
had the feedback

9/11/64

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64794.8211 of previous page worked quite well for the granule cell problem.

deep pos $V_e \approx 3 \times (.94) \approx 3 \text{ mV}$

~~deep~~ superficial neg $\approx 3 \times (-.73) \approx -2 \text{ mV}$

with timing pretty well synchronous

However, decided that there is probably an earlier phase of granule cell soma & trunk inhibition which overlaps & distorts initial cell transient.

Therefore, set up next problem with this in mind.

64794.8212 Not bad as a first try, but decide to have some E in dendritic periphery, and also to strengthen E in cp. 8 ret to 12 also, try to minimize arbitrariness.

64794.8213 ^{BEB} goofed by reversing B & BIC cards for $KES = 3$

← rerun with this corrected & with minor changes.

64794.8214 (9/12/64) pretty fair but it looks as though 5 & 6 should be more inhib. for $KT = 18-31$
8-12 " " " excit. for $KT = 14-17$
also, overall sink could be slightly weakened.

∴ add on KES at $KT = 12$, add flattened J & make E build better

PTPT 8211 Δ primary force worked quite well for the secondary cell problem.

deep pos $V_e \approx 3 \times (.94) \approx 3 \text{ mV}$
~~deep pos neg $\approx 3 \times (.94) \approx 3 \text{ mV}$~~

with turning pretty well synchronous

... pointed that there is probably an earlier phase of ... will cause a trunk initiation in which ... control cell transient ... set-up not problem with this in

PTPT 8212 Not bad as a first try, but didn't to have some E ... and also to ...

PTPT 8213 good ... $KE1 = 3$... with minor changes.

PTPT 8214 (11/10/81) pretty fair but it looks as though ... $KE1 = 12$...

9/11/64 64794.8800 Series continued from p. 66 + 65 74

64794.8821 Production Run (9/4/64) N58=8
IFVE=1, IFAB=+1 UD=200, $Z=.57$
corresp to $\Delta Z=.07$

Hot kinetics, passive dendrites
no synaptic E
Perfectly good results, but meant to
have UD=100.

64794.8822 corresponding run for ~~the~~ active dendrites

64794.8824 Dendritic spike was essentially synchronous
apparent ^{intracell} correl. bel. $\approx .012$ for $.567$
approx 400 μ for .04 msec
approx 10 m/sec

Sign of reflected outflow

Looking at extracellular dendritic pot.

it is possible, but not really legitimate, to
coax out a 1.2 m/sec figure by
taking (-) crossover for ~~some~~ pts 4-8
and neg peak for 11 & 12

However, near synchrony yields small
amplitude extracellular pots.
giant extracellulars are good.

1/11/64 LHTM. 8800 Series continued from p. 66 + 67 74

LHTM. 8821 Production Run (P/P/64) 128=8

UD = 200.	128 = 8
UD = 100.	

FEVE = 1, FEVB = +1

Hot binder, porous substrate, no synaptic C

Perfectly good results, but meant to be 100. UD = 100.

LHTM. 8822 Corresponding run for active substrate

Residual sphere was essentially spherical

apparent coat. vol. of .015 for .85

apparent 4000 for .04 mass
apparent 10 m/sec

Size of reflected coat thickness

Looking at extracellular substrate part.

it is possible, but not really legitimate, to

copy out a 1.2 m/sec figure but

looking (+) crossover for opt H-8
and resp peaks for H-72

However, your impression yields well

extracellular substrate part.

part extracellular are good.

9/11/64

✓

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64794.8823

VD reduced to 100.

$$\frac{USD}{USA} = \frac{400.}{100.} = 40$$

$$NJD = 5$$

$$IFVE = 0, IFAB = 0$$

$$I.C. = 0.2 \text{ in dendrites + soma except cpt. 9}$$

Active Case gave synchronous dendritic spike
Passive Case blocked at soma

This shows again that cannot have simple pair.

64794.8824 similar, with $NJD = 10$

Active Case had very little axon-soma delay
& very little dendritic
increasing latency.

Passive Case blocked at soma.

64794.8825 same as .8823 with $IFVE = 1, IFAB = -1$
except cpt. 9 also has $I.C. = .2$

It is amazing to note how the 0.2 in cpt. 9
facilitated axon-dendritic invasion over 8823

In 8823, the soma fired at $kt = 17$

In 8825, the " " " " - 14

and the dendritic spike is almost precisely synchronous

Consequently, V_e peak at soma is only, ~~0.186~~ 0.0186 mV
negligible amplitude. ~~0.186~~

VD checked to 100.

64774.8823

$\frac{USD}{A24} = \frac{400}{100} = 4$

WID = 2

I.C. = 0.2 in brackets + some
off of P.

Active case gone synchronous dentritic spikes
Passive case blocked at source

This shows again that count rate spikes pass.

64774.8824 similar, with WID = 10

Active case had very little open source delay
off very little dentritic
however latency
Passive case blocked at source.

64774.8825 same as 8823 with I.F.V.E = 1, I.F.A.B = -1
offset off P. about I.C. = 0.2

It is necessary to note here the 0.2 in off P.
facilitated open dentritic movement over 8823

at 8823, the same fact of KT = 17
at 8822, the " " " " " "

and the dentritic spikes in almost precisely synchronous

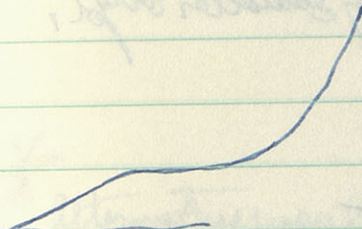
Component of the packet source is only
V

9/11/64

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64794.8826 same as 8825 except that $F.C. = 0.3$ in dendrites
 $IFVE = 0$, $IFAB = 0$

active soma & dendrites fired ahead of 2 & 3
clearly dendritic I.C. above threshold.
for dendritic spike



Passive case was barely threshold for soma.
Took off after some delay

Again proves difficulty of simple active-passive pair.
Won't work with same I.C.

64794.8827 here $NJD = 10$ $IFVE = 1$, $IFAB = -1$
 $F.C. = 0.15$ in soma & dendrites

Dendritic spike very nearly synchronous
Small extracellular

neg peak of soma = -0.34 mV
Equipotential contours not too far off,
but amplitudes are small.

64794.8828 same as 8827 ($NJD = 10$)
but with $IFVE = 0$, $IFAB = 0$
 $F.C. = 0.3$ in dendrites only

Active case, cpts 9-14 fired before 2-8

Passive case, barely threshold for soma.

64794.8831 showed that $RBSQ = 0.5$ had a slight effect compared with 8825, but not serious.
all spikes now home
~~Dendritic spike now has slightly smaller ampl.~~

.8832 blocked at soma

Decided to set up

.8833 with $B = .05, .04, .03, .02, .01$
for each KEJ

and .8834

.1, .08, .06, .04, .02

9/11/64

(9/12/64) opposite page

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Setup 64794.88³¹~~25~~ & .8832

.8831 to test effect of reducing RBSQ from 1.0 to 0.5

.8832 to test idea of getting decremental conduction in the dendrites by slugging C into the dendrites, graded toward periphery & also reducing ROUTC from 10. to 5.

* Alternative would be to modify program to permit UD to be nonsymmetric

This is related to notion that buildup of I is what causes soma to fail when loaded with passive dendrites & that this has resemblance with accommodation & can give grades of decremental conduction.

Maybe Dick FitzHugh's concern about the possibility of a second stable state can be turned to profit here. Perhaps this is an accommodative state whose stability need not be absolute because we could bring in a slower recovery process.

1/11/84

Stop CH74.8835 - 8835

had 8835 to test effect of adding RB28 from 0.2 to 0.5
 to test effect of adding RB28 from 0.2 to 0.5
 to test effect of adding RB28 from 0.2 to 0.5
 to test effect of adding RB28 from 0.2 to 0.5
 to test effect of adding RB28 from 0.2 to 0.5

This is related to matter that brought up of 2 if
 what causes, seems to (in)crease labeled
 with lower densities of that this has
 membrane with accumulation of low
 your grades of basement membrane.
 80.00, 80.00, 80.00
 Maybe Dr. Fitzhugh's concern about the possibility
 of a second stable state can be turned to help
 here. Perhaps this is an accumulative state
 whose stability need not be absolute because
 we could bring in a slower recovery process.

population of mitral cells during antidromic invasion.
 The other consists of a different sequence
 of membrane potential gradients in individual
~~neurons~~ cells of the granule cell population.
 Mitral-GEC and Granule-GEC.

9/11/64 Yesterday Gordon & I discussed w/itups

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Need to distinguish clearly between the apparent phases of an observed extracellular potential transient and the hypothetical underlying generators of the extracellular current which produce these potentials.

Underlying inhomogeneity or non-uniformity in the membrane of a single cell is needed to generate extracellular current. Can be a non-uniform conductance change, or simply a non-uniformity of ^{residual} membrane potential.

Possible Names

ULCGI underlying current generating inhomogeneity

* GEC Generator of Extracellular Current
(in general, can include electrodes)

NGEC Neuronal Generator of Extracellular Current

NMGEC Neuronal Membrane Gradient which Generates Extracellular Current

But perhaps GEC is best, with $\#$ of elaboration.

Model assumes that 1st approx can be achieved by means of two GEC. One of these consists of the sequence of membrane potential gradients in each cell of the \rightarrow

Need to distinguish clearly between the apparent
 phases of an observed after cellular potential
 transient and the underlying ionic mechanisms
 generators of the intracellular current which
 produces these potentials.

independent
 cellular mechanisms or non-uniformity in
 The well known of a single cell is needed to
 generate after cellular current. In the
 non-uniformity (and hence change or simply
 a non-uniformity of potential)

Particle Motion
 UICGI

*
 GFC Generator of Intracellular Current
 (Intracellular current includes electro)

NEFC Normal generator of intracellular current

NM & GFC Normal Membrane Potential
 which generates intracellular current
 in synchronous with the potential
 in the membrane potential
 The difference that appears in the membrane potential
 the GFC. The difference of the membrane potential
 membrane potential gradient in each cell of the

9/11/64

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The paper will need a table of Definitions, including such items as

GEC

Mitral - GEC

Granule - GEC

E

g

CORE

USD/USA \equiv Geometric Hurdle

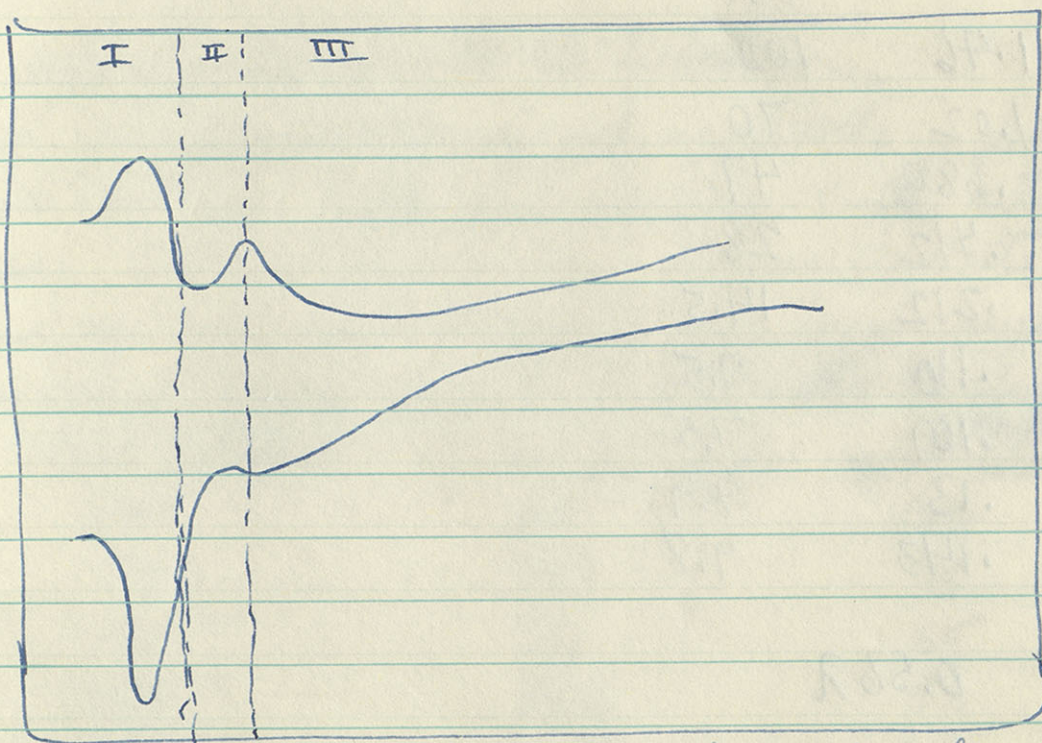
Z-length

Shunt Factor (External Potential Divider)

Response Periods I, II, III

Kinetic Constants

Increase of latency with Distance.



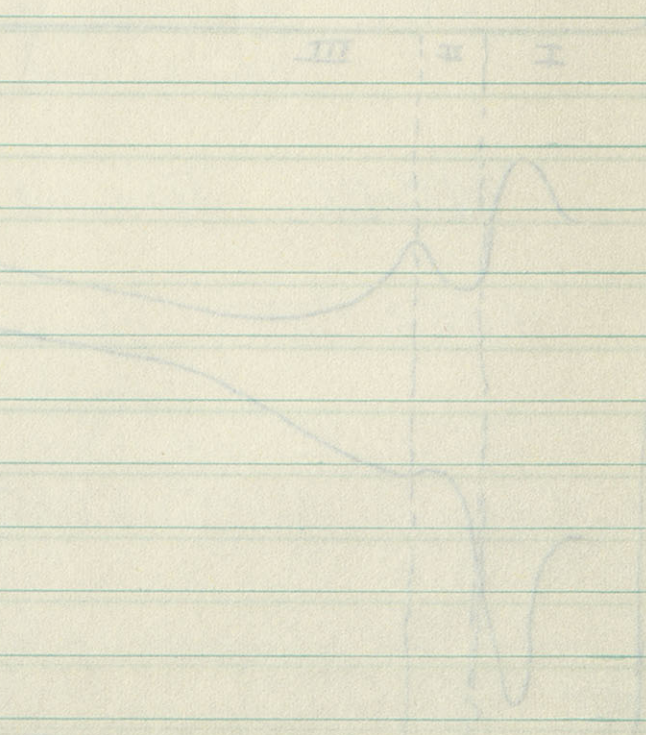
slight shift of I-II boundary probably due to ~~overlap~~ from granule GEC

Attenuation of neg. peak is a crutch
 Should not present, better to present V_e vs depth
 at several different times

peak neg personal
 64794.8821

		$\%$
4	1.46	100
5	1.02	70
6	.680	47
7	.412	28
8	.212	14.5
9	.110	7.5
10	.109	7.5
11	.13	8.9
12	.143	9.8

0.56 λ



9/4/64

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Some quantitative checks, also plot of attenuation

$$\text{in } 64791.0669 \text{ (active)} \quad \text{at soma level} \quad \left| \frac{\text{pos peak}}{\text{neg peak}} \right| = \frac{1.13}{1.59} = 0.71$$

$$\text{at glomerular level} \quad \left| \frac{\text{peak neg}}{\text{peak pos}} \right| = \frac{.285}{.385} = 0.74$$

which verifies that theoretical surface record is inversion of deep record

$$\therefore \text{peak to peak amplitude: } \frac{\text{Soma}}{\text{glom}} = \frac{2.72}{0.67} = 4.06$$

which comes directly from potential divider assumption of the model

$$\text{in } 64791.0666 \text{ (passive)} \quad \text{at soma level} \quad \left| \frac{\text{pos peak}}{\text{neg peak}} \right| = \frac{.451}{1.43} = 0.315$$

$$\text{at glomerular} \quad \left| \frac{\text{neg}}{\text{pos}} \right| = \frac{.115}{.345} = 0.334$$

The data consulted seems to lie in between.

Also, when ~~decrement~~ of neg peak amplitude is plotted vs distance find that exp. falls more sharply than active dendrite case, but more slowly than passive dendrite case.

Also, exp. case does not seem to give a min. amplitude as record turns over? This fits better the short passive case.

	$.0669 \%$ ^{max} of neg peak	$.0666 \%$ ^{max} of neg peak _{passive}	approx data _{shorter}
pts 4	100	100	100
5	99	55	75
6	92	26	65
7	74	10.5	53
8	37	6.8	40
9	18	8	40

1.25A

.625A

some quantitative checks, also plot of distribution

17.0 = $\frac{11.1}{1.28} = \left| \frac{\text{observed}}{\text{expected}} \right|$ level same to (actual) P=0.195 P=0 in

15.0 = $\frac{225}{285} = \left| \frac{\text{observed}}{\text{expected}} \right|$ level same to

... level of ... in ... that ...

or maybe neg. everywhere due to current flow to the terminal sinks of afferent fiber terminals, which would be most neg. deep and less neg toward surface (an external shunting current)

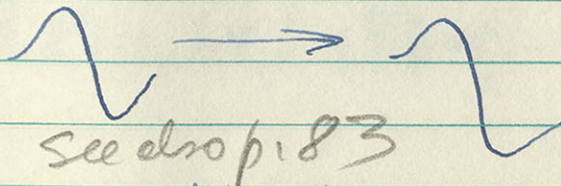
Table with columns for values (e.g., 100, 25, 26, 10.2, 8.8, 525, 1325) and rows of data.

9/11/64

(9/10/64)

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Although the computed surface record is a perfect inversion, with rescaling, of the deep record, this is not true of the experimental record. The experimental surface record tends to favor the neg peak (II) over the pos (I)



see also p. 83

the crossover & peaks seem a little earlier.

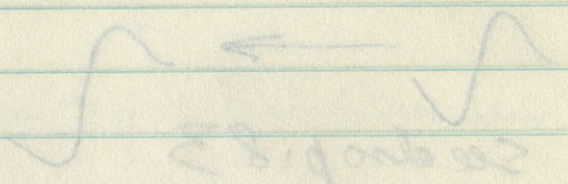
This might all be explained by an overall neg drift which might be an early effect of the granule-GEC

This idea requires that granule cells receive some early inhib. input at the same time as the mitral cell soma repolarizes. Gordon says that this is possible ~~in terms~~ by means of other fibers in the stimulated tract; these are large and would conduct fast enough. He wants to recheck that anatomical & physiological evidence.

Furthermore, if this stands up, it could account for less shift of the mitral soma level extracellular record, because there we are near zero contours (unif.) of the granule cell field. Input could even start on the neg side of zero contours. This could probably account for the imperfect "phase" ~~and~~ relation of between the surface & mitral cell level records. This complication need not be discussed at beginning of paper. There might focus on the inversion aspect of these records

Although the computed surface record is a perfect mirror
 with recording of the deep record. This is not true
 of the experimental record. The experimental surface
 record tends to favor the neg. peak (I) over the pos. (II)

of the crossover & peaks occur
 a little earlier.



This might all be explained by an overall neg
 shift which might be an early effect of the
 granule GFC.

This also explains the granule cells
 record some early input at the same
 time as the motor cell some responses. It
 says that this is possible by means
 of other fibers in the stimulated tract. There
 are back and would account for enough
 we want to check the anatomical & physiological
 evidence.

Furthermore, if this starts up
 it could account for the shift of the initial
 some level of subcellular level, because
 there we are near zero current (initial) of the
 granule cell field. If it could even start
 on the red site of subcellular. This
 could probably account for the imperfect phase
 relation between the surface &
 motor cell level records. This comparison may
 not be discussed & part of paper. There might focus on the
 inversion aspect of the motor

9/12/64 Brief review of the 64794.8100 series which attempts to compare three cases

- (a) dendritic E alone to give spont. firing
- (b) plus somatic J to suppress " "
- (c) plus antidromic which helps dendrites to fire ahead of soma

64794.8111, 2+3 (9/4/64) J was too strong at soma, but did not prevent periph dendritic spike, some E pulses reveal report or accommodated state

64794.8114, 5+6 (9/5/64) here J was too weak. also some cards reversed.

64794.8117, 8+9 (9/8/64) goofed with $E = .075$ format picked up 50.

(9/9/64) rerun with $E = 0.07$ needs stronger J

~~64794.8121~~

64794.8121, 2+3 (9/10/64) getting better, but need to delay antidromic spike & avoid $KT = 12$ J

64794.8124, 5+6 (9/10/64) Here delayed spike by adding J to axon. Soma not invaded antidromically, otherwise pretty close.

64794.8127, 8+9 reduce grench + ROUTE use NSP (9/11/64) & simplify I.C.

64794.8131, 2+3 (9/12/64)? machine error? further reduce ROUTE goofed in setting VSP = 5. instead of 0.5

9/14/64

83

Some surface records of Prod 3 of April 12
also May 16
of Prod 2

Surface pos. lines up well with the deep
negativity. surface neg not so obvious

But in May 2 (illustration series)

May 31 Prods 1 & 2
surface records small

~~A surface pos. leads deep neg.~~
presumably $\approx \frac{1}{20}$ pot. divider
effect.

probably more surface saline

March 29 Surface + leads deep neg slightly
Surface neg. might be due to offshore
axon GEC

some surface vegetation

surface vegetation
some surface vegetation

Part in May 2 (Columbian series)

May 31 - Probs 14 -
surface vegetation

~~Surface vegetation~~

Probs 14 -
surface vegetation

Probs 14 -
surface vegetation

Probs 14 -
surface vegetation

surface vegetation

9/15/64

84

64794.8833 & 4 attempt & decrementally conducted dendritic spike I not enough
I.C. plus E was too much

↑
Actually, the dendritic spike occurred before the luteal spike. Could run with dendritic I.C. reduced to zero.

64794.8215 granule cell approx worked pretty well
Could smooth the E somewhat at $KEJ = 3 \& 4$.

Maybe eliminate E from $KEJ = 1$

64794.8131, 2 & 3 Dendritic E , I & antidromic series axonal spike failed because of axonal I also initiated too late
The E alone is OK and will not need to be repeated is. 64794.8133
very similar to 64794.8129

rel. IR drop along cone
of extracellular volume
associated with each
mitral cell.

IR drop rel. to surface
For a const. radial current.

		Rescaled increments
surface	0	.199
opt. 9	0.2	.066
8	0.265	.072
7	0.337	.080
6	0.417	.090
5	0.507	.101
mitral soma <u>4</u>	0.608	.114
	0.722	.130
	0.852	.149
1mm. deep	1.000	<u>1.001</u>

But now the question is: For current generated outside the conical element, how much IR drop is there from INDelectrode to the bulb surface? How

9/15/64 - 9/16/64

Consider the radial aspect of R_e in Olfactory Bulb.

Estimate Radii of curvature at different levels

- bulb surface ~ 2.0 mm
- glomerular level 1.7
- mitral cell 1.3
- deep granular 1.0

$$\frac{dR}{dp} = \frac{R_e}{4\pi p^2}$$

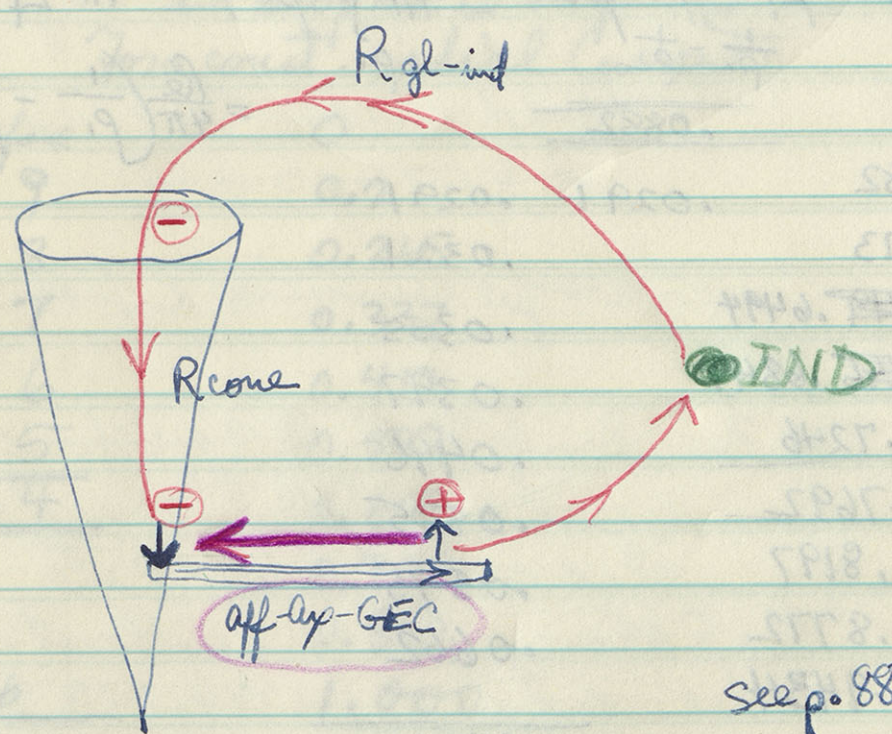
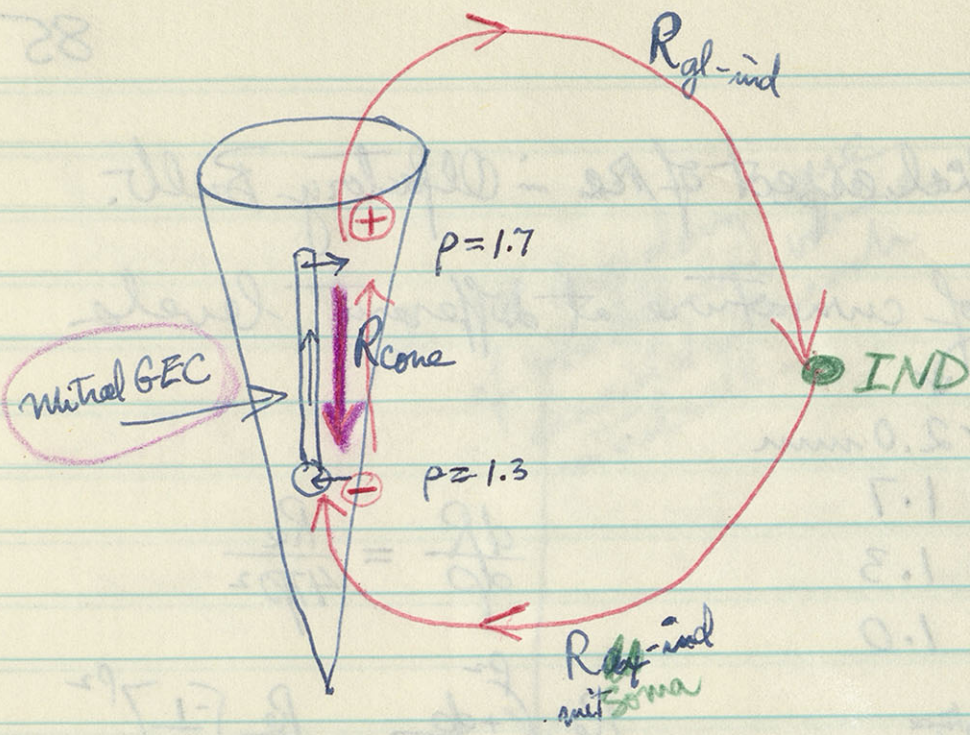
let p represent radius, then ^{resistance} ~~from~~ p_1 to $p_2 = \frac{R_e}{4\pi} \int_{p_1}^{p_2} \frac{+dp}{p^2} = \frac{R_e}{4\pi} \left[\frac{-1}{p} \right]_{p_1}^{p_2}$

$$= \frac{R_e}{4\pi} \left(\frac{1}{p_1} - \frac{1}{p_2} \right)$$

	p	$\frac{1}{p}$	$\frac{1}{p_1} - \frac{1}{p_2}$	
surface	2.0	.50	<u>.0882</u>	
opt 9	1.7	.5882	.0291	.0291
8	1.62	.6173		.0321
7	1.54	.6494 .6494		.0355
6	1.46	.6849 .6849		.0397
5	1.38	.7246		.0446
some 4	1.30	.7692		.0505
opt 3	1.22	.8197		.0575
2	1.14	.8772		.0662
1	1.06	.9434		<u>.4434</u>

rescale

does this compare with the drop along the cone.



But now the question is: for current generated
 outside the kernel element, how much IR does
 it have, even at positions that are not directly

9/16/64

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Consider the possibility that $R_{\text{cone}} = (R_{\text{gl-ind}} + R_{\text{ax-ind}})$

Then the -2mV difference between the deep and the surface record means that open circuiting the external path would ~~increase~~ make the deep record equal -4mV (now isolated from outside)

Since we estimate that $\frac{R_{\text{gl-ind}}}{R_{\text{ax-ind}}} \approx \frac{1}{4}$

We would have $R_{\text{gl-ind}} = 0.2 R_{\text{cone}}$
 $R_{\text{ax-ind}} = 0.8 R_{\text{cone}}$

In this case, the current due to off-ax-GEC would give IR drops from $\left\{ \begin{array}{l} \text{IND to surface} \approx \text{glom} \\ \text{surface} \approx \text{glom to deep} \end{array} \right\}$ in the ratio $\frac{R_{\text{gl-ind}}}{R_{\text{cone}}} = \frac{1}{5}$
 $\frac{\text{surface ampl}}{\text{deep ampl}} = \frac{1}{6}$

However, consider other possibilities

$$R_{\text{external}} = 100 * R_{\text{cone}}$$

Then $R_{\text{gl-ind}} = 20 * R_{\text{cone}}$
 $R_{\text{ax-ind}} = 80 * R_{\text{cone}}$

and $\frac{R_{\text{gl-ind}}}{R_{\text{cone}}} = 20$

and $\frac{\text{surface ampl}}{\text{deep ampl}} = \frac{20}{21}$
 for off-ax-GEC

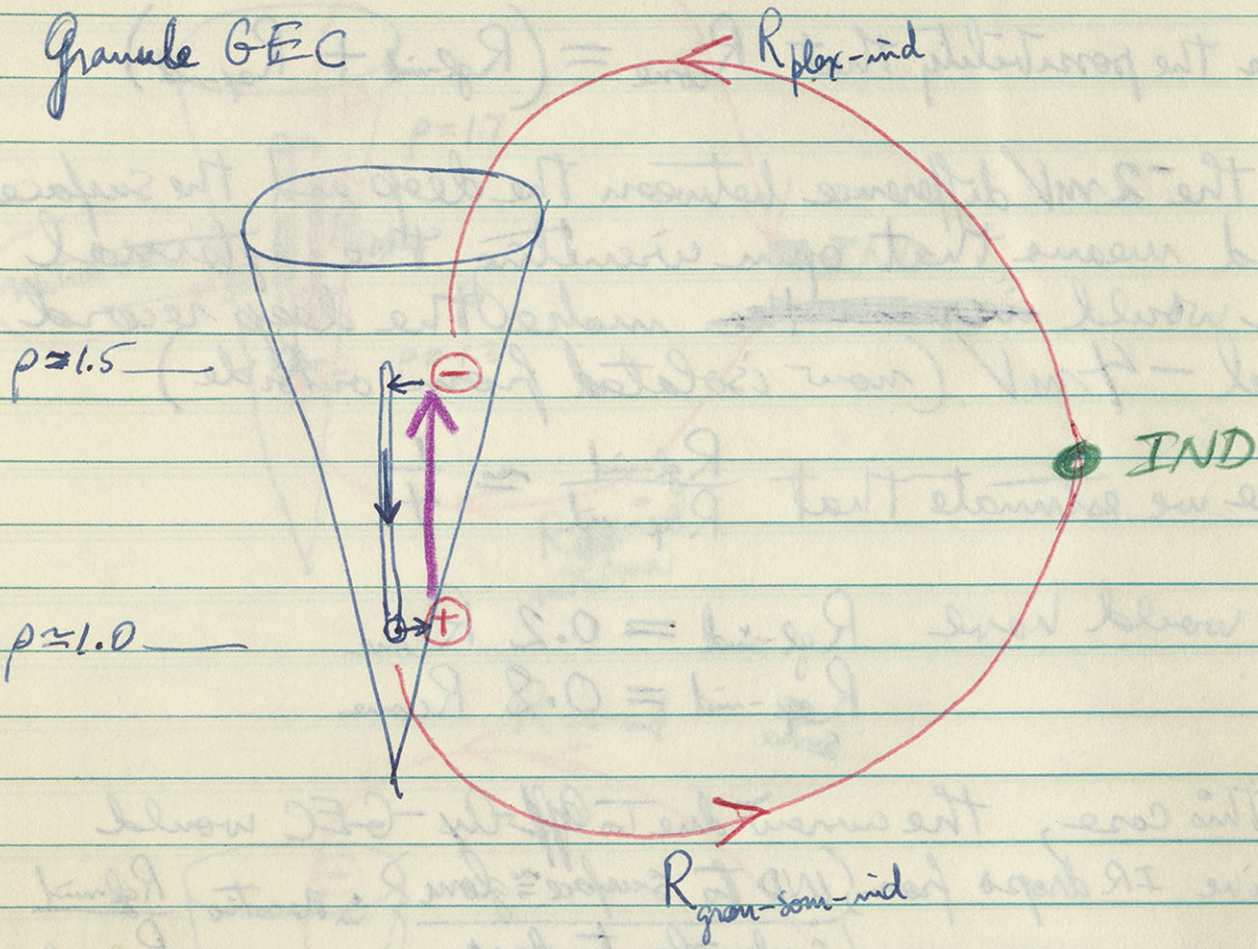
$$R_{\text{external}} = 5 * R_{\text{cone}}$$

Then $R_{\text{gl-ind}} = R_{\text{cone}}$ see next page
 $R_{\text{ax-ind}} = 4 * R_{\text{cone}}$

and $\frac{R_{\text{gl-ind}}}{R_{\text{cone}}} = 1$

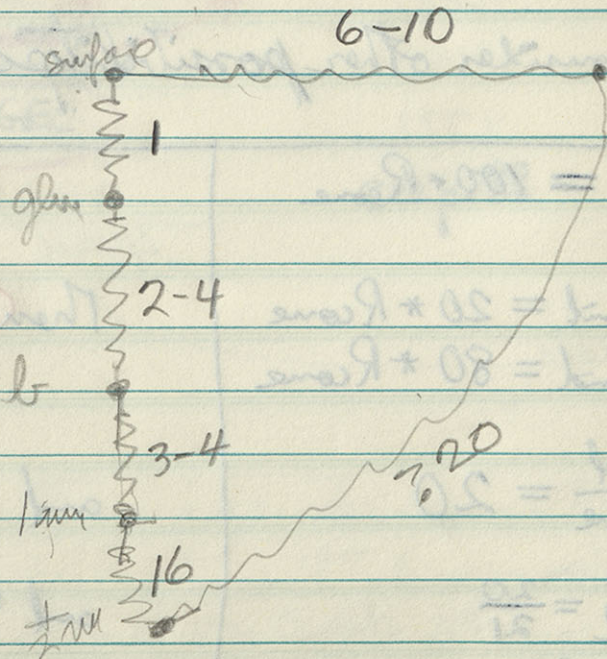
and $\frac{\text{surface ampl}}{\text{deep ampl}} = \frac{1}{2}$

Granule GEC



60-90-06-09

- $R_{glom-ind}$
- $R_{plex-ind}$
- R_{mb-ind}
- $R_{gst-ind}$



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Compare conical resistance from $\rho = \frac{1}{2} \mu\text{m}$ to $\rho = 1 \mu\text{m}$ $\frac{1}{2} - \frac{1}{1} = 1$
 $\rho = 1 \mu\text{m}$ to $\rho = 2 \mu\text{m}$ $1 - \frac{1}{2} = \frac{1}{2}$
 $\rho = 2 \mu\text{m}$ to $\rho = \infty$ $\frac{1}{2} - 0 = \frac{1}{2}$

However R_{cone} is from initial soma level to glomerular level
 $\rho \approx 1.2$ to 1.3 $\rho = 1.7$ to 1.8

\therefore this resistance $\propto \begin{cases} \frac{1}{1.2} - \frac{1}{1.8} = .833 - .556 = .277 \\ \frac{1}{1.3} - \frac{1}{1.7} = .769 - .588 = .181 \end{cases}$
 say 0.2 to 0.25

Resistance from glom to surface $\propto \begin{cases} \frac{1}{1.7} - \frac{1}{2} = .588 - .5 = .088 \\ \frac{1}{1.8} - \frac{1}{2} = .556 - .5 = .056 \end{cases}$

Resistance from surface to ∞ $\propto \frac{1}{2} - 0 = 0.5$
 surface to $\rho = 4$ $\propto \frac{1}{2} - \frac{1}{4} = 0.25$

Resistance from $\rho = 1$ to $\rho = 1.3$ $\propto 1 - .769 = 0.231$
 $\rho = \frac{1}{2}$ to $\rho = 1.3$ $\propto 2 - .769 = 1.231$

How much of this applies can be estimated from deep gradients caused by the external loop current, which would be $\frac{1}{6}$ of the GEC current for the case $R_{\text{ext}} = 5 \times R_{\text{cone}}$

$R_{\text{glb}} \text{ mid } \approx 10$
 $R_{\text{im}} \text{ mid } \approx 40$

$\therefore \frac{R_{\text{ext}}}{R_{\text{cone}}} \approx \begin{cases} \frac{50}{2.5} = 20 \\ \frac{40}{4} = 10 \end{cases}$

$p = 1 \text{ mm top} = 2 \text{ mm to } p = 1 \text{ mm} = 1 \text{ mm} = 1 \text{ mm}$
 $p = 1 \text{ mm top} = 2 \text{ mm} = 1 \text{ mm}$
 $p = 2 \text{ mm top} = \infty = 1 \text{ mm}$
 $1 - \frac{1}{2} = \frac{1}{2}$
 $0 - \frac{1}{2} = \frac{1}{2}$

However, base is from initial same level to glass level
 $p \approx 1.5 \text{ to } 1.3$
 $p = 1.17 \text{ to } 1.8$

This is not true
 $1.2 - 1.8 = .88 = .225 = .255$
 $1.3 - 1.7 = .4 = .28 = .181$
 say 0.25 to 0.32

Restored from base to surface ∞
 $1.2 - 1.8 = .88 = .225 = .255$
 $1.3 - 1.7 = .4 = .28 = .181$

Restored from surface to ∞
 $1.2 - 1.8 = .88 = .225 = .255$
 $1.3 - 1.7 = .4 = .28 = .181$

Restored from $p = 1$ to $p = 1.3$ ∞ $1.2 - 1.8 = .88 = .225 = .255$
 $p = \frac{1}{2}$ top $p = 1.3$ ∞ $1.3 - 1.7 = .4 = .28 = .181$

How much of this species can be estimated from the...
 cannot by the optical base current, which would
 be 1/2 of the DC current for the case $R = 2 \text{ } \Omega$

1000
 200
 10

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Offspring Axon GEC would generate same current as mitral axon spike if $\Sigma d^{3/2}$ were the same.

Mitral cell axon spike $\approx \frac{1}{25}$ current of mitral soma spike because CORE estimated as 0.04 see p. 70

assuming similar spike duration & kinetics

Cajal says these offspring axons are sparse in the tract but they bifurcate several times and then form a very extensive arborization (plexus) in granule cell layer.

Suppose the plexus $\Sigma d^{3/2}$ were as much as ten times that of mitral axons. Then we would expect $(10)(.04) = 0.4$ of mitral soma current,

& thus about 0.8 mV neg peak deep

and from bottom corner of p. 86, surface neg might be 0.4 mV

Note: to get anything at surface, require that $\frac{R_{\text{surf-vid}}}{R_{\text{cone}}} > 0$ not negligible

Need to modify program.

$KVE = 1$ computes V_e for no shunt

$KVE = 2$ " " for ϵ shunt current
(potential divider effect)

$KVE = 3$

(A) effect of significant currents including axonal cpts

(B) effect of conical R_e including axonal compartments

Could combine (A) with $KVE = 2$

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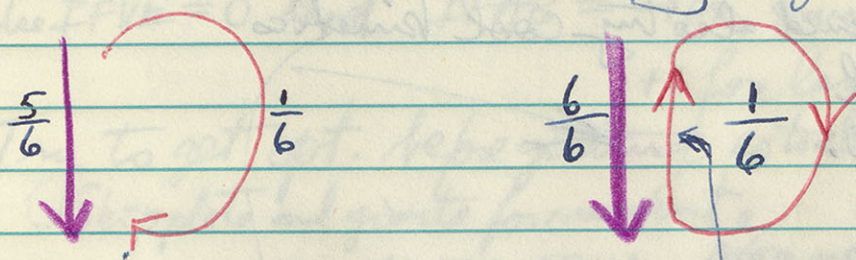
89

Refer back to p. 29 of Book 3

With some V_i is a voltage source which puts out a current determined ~~by~~ by Z_N , which depends mainly upon R_m , R_i and geometry. Presumably not much affected by R_e . If this is so, small changes in external conductance would not change the total amount of external current.

Thus mutual GEC is a current generator.

If the external loop path has a conductance which is not negligibly small, it must divert some of the GEC current & reduce the "apparent ext. driving potential". This is equivalent to imposing a steady current along R_e , which would cause a linearly-graded drop.



This is linear gradient to superimpose for

This is final (net) resultant

~~KVE=2~~

KVE=1

If 41-44 series gave trouble, consider using \pm FFTEST to determine whether BEB & BJC are needed.

St St. with I.C.

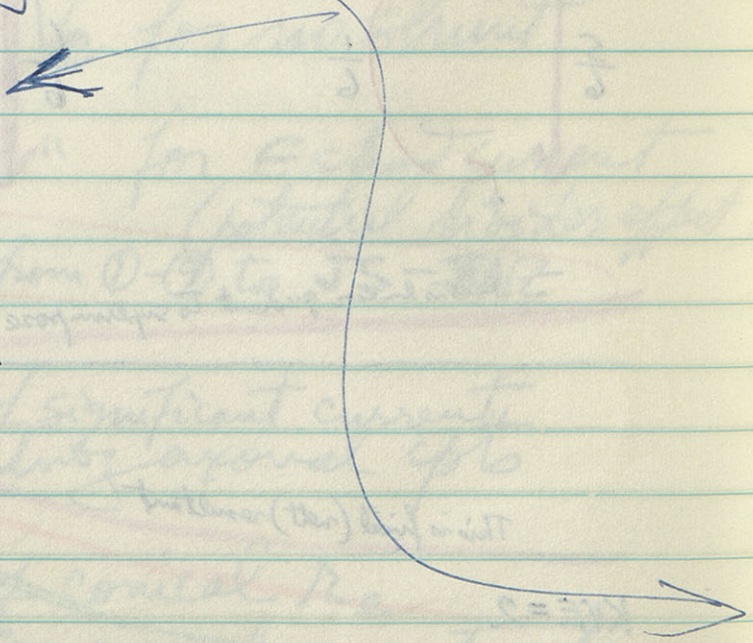
might save computation time by making USA = 5. USD = 200.

instead of 10. 400.

These are hot kinetics.

Should also try cool kinetics

	Hot	Cool
RACT	600.	400.
RBSI	1.	1.
RBER	80.	80.
QA	25.	20.
RowB	40.	50. → 35.
RowC	10.	10.
QB	25.	20.
AFPOS	.1	.1



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Setup new computations.
compare with p. 84

90

64794.8835 & 6 The I.C. were removed from 33 & 34
 also doubled f values
 in 35 first BEB & BJC pair reversed & ruined run
 in 36 This was OK, but cpts 4 & 5 fired a little
 too soon & 8 perhaps too late.
 Probably best to weaken E & perhaps make uniform,

for 748



looking back over 8831 - 8836, decide to try 2 of 36
 together with I.C. = 0.1 ^{zero in one case} in some & dendritic cpts
 and $B = 0.05$ in " " " " " "

for 64794.8837 & 38

Increase to 10 compartments & try again for decremental cond.
 except 1.5 in 9th

Compare with p. ⁷⁵ 76 64794.8826, 27 & 28
 23, 24, 25

Use IFVE = 0 and IFAB = -1 for small I.C.,
 +1 for larger I.C.

Try to get opt. before getting extracellular.
 Skip plots and graphs for moment.

Setup 64794.8841 ~~ADD~~ = 5 act.
 42 NJD = 5. pass

64794.8843 NJD = 10 act.
 44 " " pass

For cool kinetics, compare with 64793.105 p. 59

New name for ^{cool} series 64794.8741 etc - 44

Note that USA = 2., USD = 80. perhaps better use 4. & 160.
 But then need to increase NSTEP

Stop your computations, compare with p. 84

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64744.883246 To IC, were removed from 33434

also double check values

in 35 first B2B + B7C pins removed + numbered in 36 this was OK, but not the 2 first cables two more of 8 pins for later. Probably not to be used 3 of pins are missing

looking back over 8831 - 8836, decide to try 36 together with IC = 0.1 in some + double check B = 0.02 in v

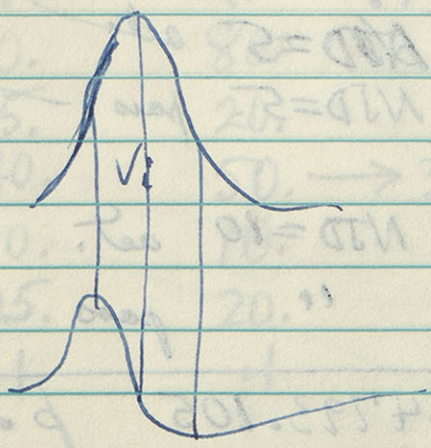
measure to 10 components to try again for document card. 64744.883148

Compare with p. 16 64744.8826, 25428

Unit VE = 0 and IFRB = -1 for small F.C.

im to get out. More active, external... 64744.8841

RBFR 80. 28 = 28
QA 25. 28 = 28
RWB 40. 20 → 35
RWC 10. 20 = 20
QA 25. 20. 44



This limiting case reduces amplitude →

$\frac{dv}{dt}$

Measure UAH = 2. USD = 80.

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Consider active versus passive

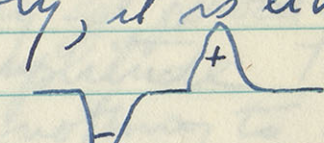
A In period I, the deep neg. and the surface pos. are provided equally well by the active and the passive, or a decremental case.

B Period II is more diagnostic, but is unfortunately experimentally muddy, because of GEC overlap.

Consider only the Mitral-GEC

Consider first only the deep record versus surface without any external path shunting.

This is like recording from an axon in oil

① If dendritic spike propagates very slowly, it is like two electrodes far apart in oil. 

The neg & pos. phases are exactly the same except for sign and displacement, provided that soma spike and peripheral dendritic spike are exactly the same & the delay is long enough that ~~each~~ when ~~one~~ electrode has spike, other electrode has rest. $V_m = E_r$

* ② However, for very fast propagation and uniform spike shape the record approaches the first time derivative, where the pos phase is smaller than the neg phase because ~~the~~ the intracellular spike declines more slowly than it rises

Consider active versus passive

In period I, the deep was... and the surface pos. and provided equally well in the active and the passive, for a substantial case

A

Period II is more dissociative, but is unfortunately experimentally infeasible because of GFC overlap.

B

Consider only the Metal-FEC

Consider first only the deep record versus surface without any external path disturbance.

This is like recording from an open in oil

① The hydrostatic spike properties very slowly, it is like two electrodes far apart in oil.

The very deep phases are exactly the same except for sign and displacement, provided that some center and peripheral hydrostatic spikes are exactly the same. If the behavior is low enough, that is, when the electrode has finite, other electrode layout.

② The hydrostatic spike behavior is very different from the surface because the hydrostatic spike is the first fundamental wave, the very first propagation and uniform expansion.

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In both cases, pot. divider effect would make surface record a reduced inversion of the soma record.

* The point is that the $\frac{dV_i}{dt}$ effect for the prop. dendritic spike does give neg (deep) larger than deep pos.

Which reduces difference from passive case.

This was, in fact, shown by 64791.0669

* This optimal active case does not so much need cool kinetics as it needs somewhat slower falling phase.

However Gordon's records indicate that this ~~part~~ of Period II is moderately sharp, at least in the illustrative records, neg in mid region

③ In the passive case, necessarily get period II disturbance to be of smaller amplitude than that in period I, but this has nothing to do with derivative of intracellular action potential. This is difference of soma intracellular spike against the later, smaller electrotonic version found at dendritic periphery.

However, period II is complicated by granule & afferent GECs.

Also, period II is more subject to any smear due differences between primary & secondary dendrites.
see next page.

In both cases, the distance effect would make surface record a reduced measurement of the same record.

* The point is that the $\frac{dV}{dt}$ effect for the trap, but the effect does give us a (very) large thin trap pro. It will reduce difference from porous case.

This was, in fact, shown by $\Delta V_{11} = 0.001$

* This official action case does not so much need cool picture as it needs somewhat above falling process.

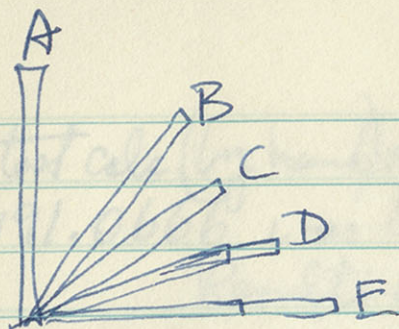
However, Johnson's records indicate that this $\frac{dV}{dt}$ of period II is undoubtedly sharp & that in the illustrative records, trap in mind region

3) In the porous case, movement of period II distance to be of smaller amplitude than that in period I, but this has nothing to do with behavior of intercellular action potential. This in differences of some intercellular sites against the later, smaller electrotonic potential found at dendritic prop/prop.

When period II is completed by jumps & offhand (etc.)

Also, period II is more subject to any given due difference between primary & secondary dendrites. See next page.

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A = primary
 B, C, D & E represent
 different sec. orientations

1st approx. Suppose intracellular events are the same in all of them. Actually, λ & length variation could cause some temporal dispersion.

B drives its current across $\frac{3}{4}$ of cone resistance of A
 C $\frac{1}{2}$
 D $\frac{1}{4}$
 E 0

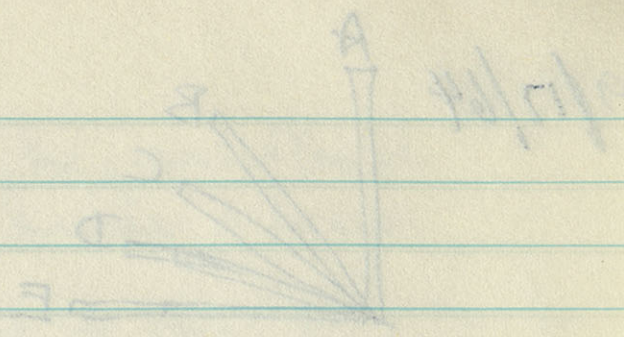
\therefore IR drops should be proportional to these
 i.e. IR drops rel. to surface.

Consider depth potentials rel. to unshunted glomerular level

cpt. levels	4	5	6	7	8	9
A primary	$1 \times (4)$	$1 \times (5)$	$1 \times (6)$	$1 \times (7)$	$1 \times (8)$	1×0
B secondary	$\frac{3}{4} \times (4)$	$\frac{3}{4} \times (5-6)$	$\frac{3}{4} \times (6-7)$	$\frac{3}{4} \times (8)$	0	0
C secondary	$\frac{1}{2} \times (4)$	$\frac{1}{2} \times (6)$	$\frac{1}{2} \times (8)$	0	0	0
D "	$\frac{1}{4} \times (4)$	$\frac{1}{4} \times (8)$	_____			
	$2.5 \times (4)$					

Dividing by 2.5, get weight factors A B C D
 0.4, 0.3, 0.2, 0.1

A = primary
 B, C, D, E secondary
 different sec. resistors



Let us say, suppose intercellular distance is same
 in all of them. Actually it is length variation
 and it causes some temporal differences.

B shows the current across 3/4 of core resistance of A
 C 1/2
 D 1/4
 E 0

IR drops across the resistor are proportional to these
 IR drops are to surface.

Under high potentials vol. to maintain glomerular level

pt. levels 9 8 7 6 5 4 3 2 1

A primary	1 x 1	2 x 1	3 x 1	4 x 1	5 x 1	6 x 1	7 x 1	8 x 1	9 x 1
B secondary	1/4 x 1	1/2 x 1	3/4 x 1	1 x 1	1/4 x 1	1/2 x 1	3/4 x 1	1 x 1	1/4 x 1
C secondary	1/2 x 1	1 x 1	1/2 x 1	1 x 1	1/2 x 1	1 x 1	1/2 x 1	1 x 1	1/2 x 1
D "	1/4 x 1	1/2 x 1	3/4 x 1	1 x 1	1/4 x 1	1/2 x 1	3/4 x 1	1 x 1	1/4 x 1
E "	0	0	0	0	0	0	0	0	0

by weight factors 0.4, 0.3, 0.2, 0.1

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A test calc. (by hand) of primary-secondary smearing.
64791.0666 was carried out.
Results attached.

Conclusion: That the crossover from surface type record to deep type record gets shifted deeper than for primary only.

In this case, the smeared ^{transient} record at cpt. (6) is in the ^{transition} crossover region, whereas the primary ~~record~~ transient at cpt. (6) was of the deep type. For the primary dendrite transient, the ^{transition} crossover type transient occurred at cpt. (7). All of these, of course, include the potential divider effect.

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for trouble-shooting

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- ② Maura Hammond
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- ~~Bob Brunelle~~

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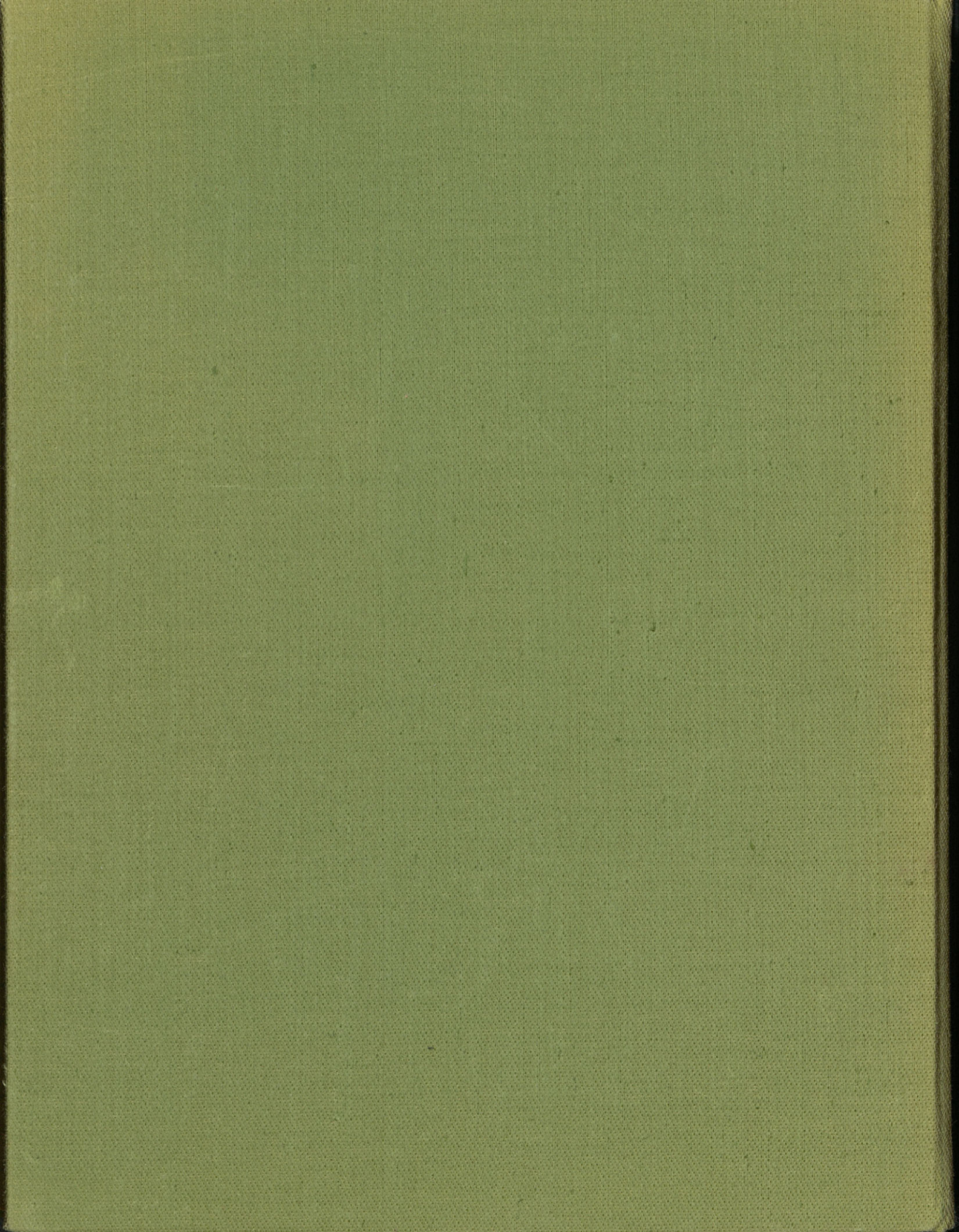
Ready Room 66184
Dolores Forcier
Mrs. Culpepper
Bobillard

Jerry Farlow 66037
Betty Garber 8

Plotter
Irving Gillespie

Photography
Mr. Godwin 62251
discussed photog. of
plotted projections of trees

p.57



9

$$\text{try } V = .4 \quad V^2 = .16 \quad V^4 = .0256$$

$$R_1 V^2 = 80 \quad R_2 V^4 = 1024$$

Sum is 1104

$$J_{SS} = \frac{1104}{200} = 5.52$$

$$\Sigma SS = \frac{1104}{55.52} = 19.9$$

$$\psi_{SS} = 0.4 - (19.9)(0.6) + (5.52)^{2.76}(.5)$$

$$= 3.06 - 11.93 = -8.77$$

$$\text{try } V = .6 \quad V^2 = .36 \quad V^4 = .1300$$

$$R_1 V^2 = 180 \quad R_2 V^4 = 5200$$

Sum is 5380

$$J_{SS} = \frac{5380}{200} = 26.9$$

$$\Sigma SS = \frac{5380}{76.9} = 70$$

$$\psi_{SS} = 0.6 - (70)(.4) + 26.9^{18.8}(.7)$$

$$= 19.4 - 28 = -8.6$$

try $V = .7$

$V^2 = .49$
 $R_1 V^2 = 245$

$V^4 = .24$
 $R_2 V^4 = 9600$

Sum is 9845

$J_{SS} = \frac{9845}{200} = 49.225$

$\Sigma_{SS} = \frac{9845}{99.225} \approx 99.2$

$\psi_{SS} = 0.7 - (99.2)(.3) + (49.225)(.8)$

$\approx 41.01 - 29.7 = +11.4$

This has crossed over

Root must be approx $.64$

$V^2 = .41$

$V^4 = .168$

$R_1 V^2 = 205$

$R_2 V^4 = 7920$

Sum is 8125

$J_{SS} = \frac{8125}{200} = 40.62$

$\Sigma_{SS} = \frac{8125}{90.62} = 89.6$

$\psi_{SS} = 0.64 - (89.6)(.36) + (40.62)(.74)$

$\approx 30.74 - 32.3 = -1.56$

Compare stability of I versus V plot

at (A)

$$\begin{aligned} \epsilon &= 0 \\ g &= 0 \\ V &= 0 \\ I &= 0 \end{aligned}$$

(C)

$$\begin{aligned} \epsilon &\approx 90 \\ g &\approx 41 \\ V &\approx 0.64 \\ I &\approx -1.5 \end{aligned}$$

What happens if we add ΔV to V by means of δ pulse.

In (A) get $\epsilon \dot{V} = -\Delta V$, which is restorative.

$$\begin{aligned} \text{In (C) get } \epsilon \dot{V} &\approx -\Delta V(1 + \epsilon + g) \\ &\approx -131(\Delta V) \end{aligned}$$

which is strongly restorative.

~~In (A) get $\epsilon \dot{g} = 0$ for instantaneous δ pulse of charge.~~

$$\begin{aligned} \text{however } \epsilon \dot{\epsilon} &= R_1 (V + \Delta V)^2 - R_1 V^2 + R_2 (V + \Delta V)^4 - R_2 V^4 \\ &= R_1 (2V\Delta V + (\Delta V)^2) + R_2 (4V^3 \Delta V + \dots) \end{aligned}$$

See how instability of middle point shows up

follows p 5
of yellow sheets

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6

Now try $V = .09$

$$V^2 = .81 \times 10^{-2}$$

$$V^4 = .656 \times 10^{-4}$$

$$R_1 V^2 = 4.05$$

$$R_2 V^4 = 2.62$$

$$\therefore R_1 V^2 + R_2 V^4 \approx 6.67$$

$$j_{SS} = \frac{6.67}{200} = .0333$$

$$E_{SS} = \frac{6.67}{50 + .033} = .133$$

$$\begin{aligned} \psi_{SS} &= .09 - .133(.91) + .0333(.19) \\ &= +.0963 - .1213 \\ &= -0.025 \end{aligned}$$

This is closer to the middle point.

Next try $V = .08$ which will probably cross ψ to pos.

$$V^2 = .64 \times 10^{-2}$$

$$V^4 = .41 \times 10^{-4}$$

$$R_1 V^2 = 3.2$$

$$R_2 V^4 = 1.64$$

$$\text{Sum} = 4.84$$

$$j_{SS} = \frac{4.84}{200} = .0242$$

$$E_{SS} = \frac{4.84}{50 + .024} = .097$$

$$\begin{aligned} \psi_{SS} &= .08 - .097(.92) + .0242(.18) \\ &= +.0844 - .0892 \\ &\approx -0.005 \end{aligned}$$

which is very close

try

$$V = .075$$

$$V^2 = .563 \times 10^2$$

$$V^4 = .317 \times 10^{-4}$$

$$R_1 V^2 = 2.81$$

$$R_2 V^4 = 1.264$$

$$\text{Sum} = 4.07$$

$$J_{SS} = .0203$$

$$E_{SS} = .0814$$

$$\psi_{SS} = .075 - (.0814)(.925) + (.0203)(.175)$$

$$= .07855 - .0753$$

$$= +.003$$

∴ Crossover is approx at $V = .077$

New, try for third crossover

Begin with

$$V = .12$$

$$V^2 = 1.44 \times 10^{-2}$$

$$V^4 = 2.08 \times 10^{-4}$$

$$R_1 V^2 = 7.2$$

$$R_2 V^4 = 8.32$$

together get 15.52

$$J_{SS} = .0776$$

$$E_{SS} = .3105$$

$$\psi_{SS} = .12 - (.31)(.88) + .0776(.22)$$

$$= .137 - .273$$

$$= -.136$$

∴ neg minimum probably lies near 0.11
if we need to go further

try $V = 0.14$

$$V^2 = 0.96 \times 10^{-2}$$

$$V^4 = 3.84 \times 10^{-4}$$

$$R_1 V^2 = 9.8$$

$$R_2 V^4 = 15.36$$

$$S_{\text{my}} = 25.16$$

$$J_{\text{SS}} = 0.125$$

$$E_{\text{SS}} = \frac{25.16}{50.125} = 0.502$$

$$\begin{aligned} \psi_{\text{SS}} &= 0.14 - (0.502)(0.86) + (0.125)^{0.03}(0.24) \\ &= 0.17 - 0.43 \\ &= -0.26 \end{aligned}$$

In other words, have further to look for this.

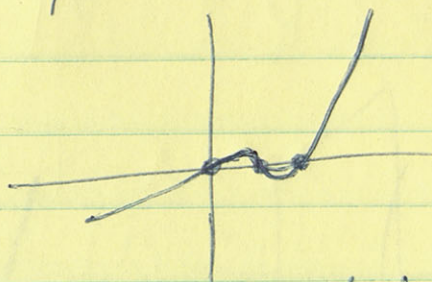
Guess around $V = 0.3$ or 0.4

When find it, need to investigate its stability.

Talked with Dick Fitzhugh

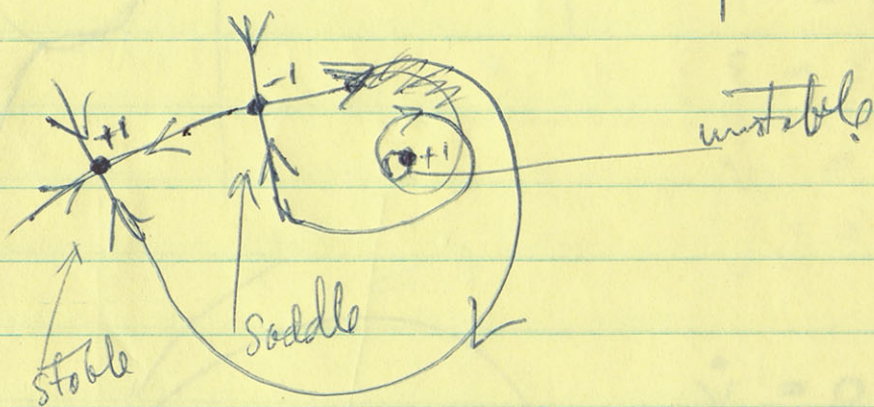
He had two suggestions

- ① Compute E_{ss} & I_{ss} for small V
 & then plot (I, V_0) curve
 two see if there are three singular
 points.



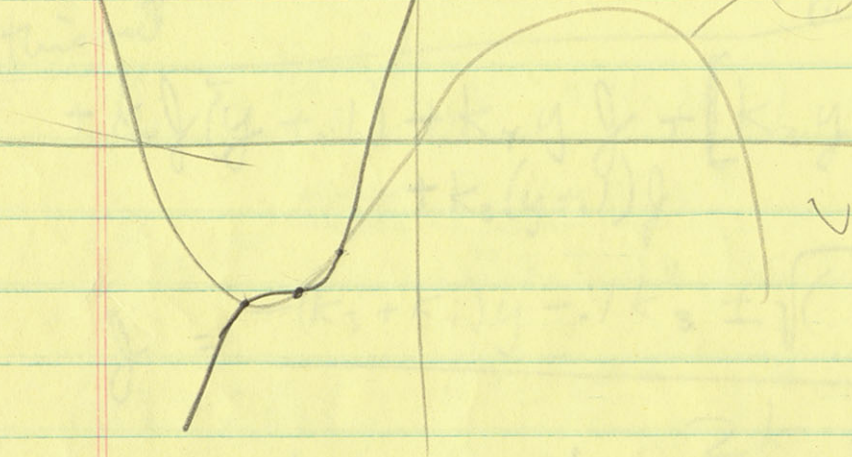
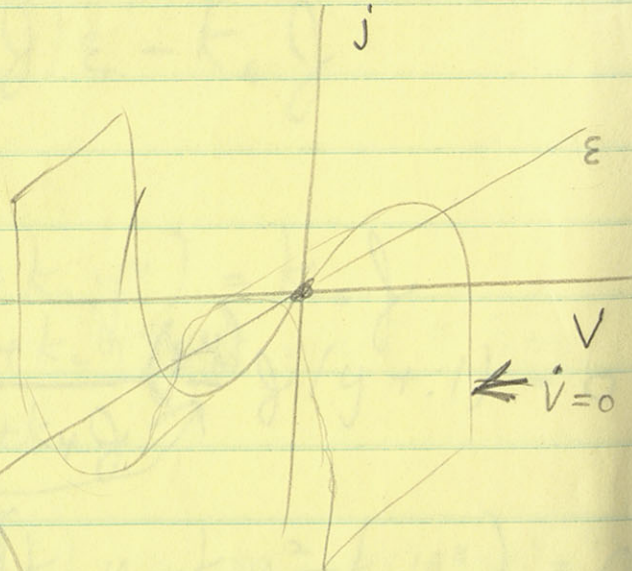
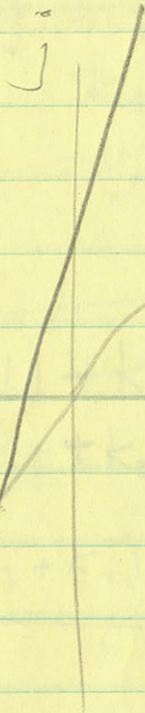
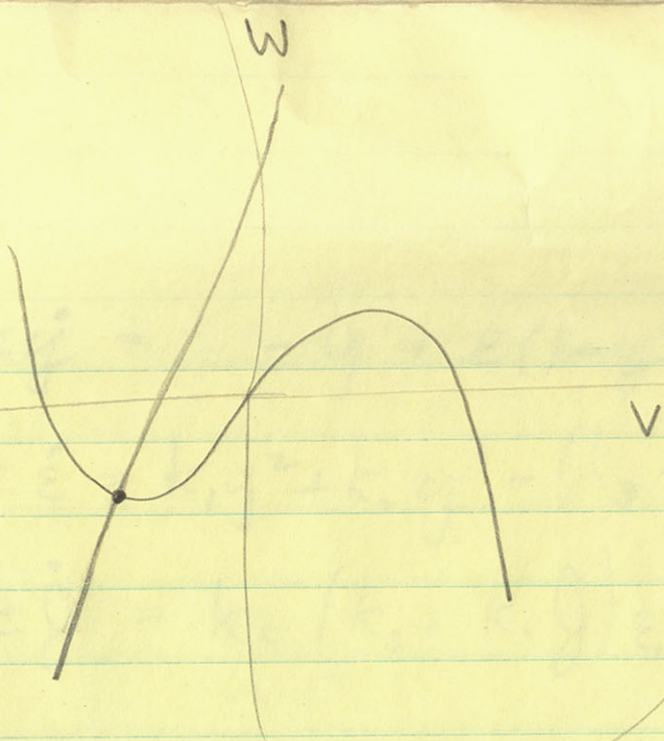
Also, investigate third to see if it
 is unstable.

He says it could conceivably be, but
 he has not met this before



also, plot I vs V

for E const. at st. st. value
 to corresp to BVP



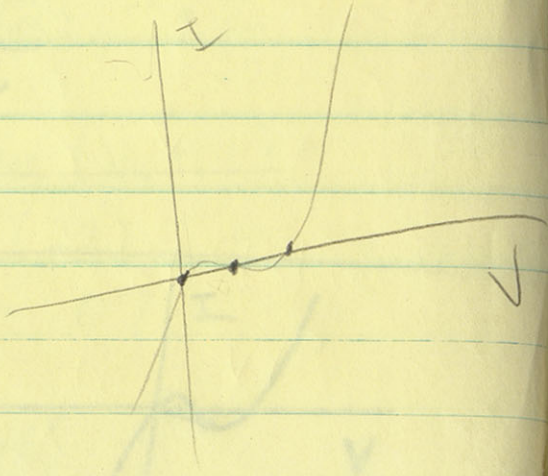
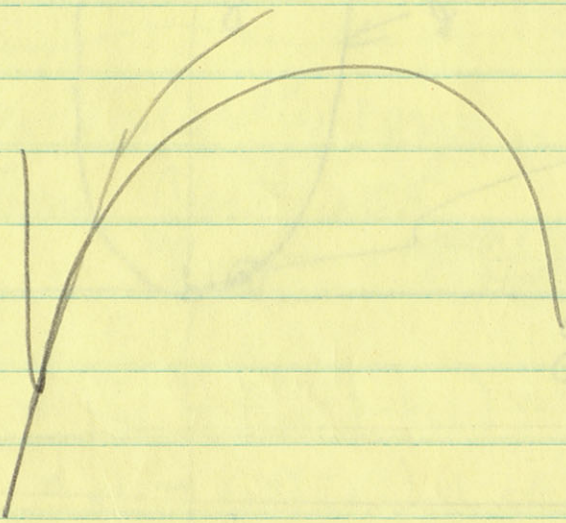
$$\dot{\epsilon} = 0$$

$$\epsilon = \epsilon_{\infty}(V, j)$$

$$\dot{V} = 0 \quad j = f(V)$$

$$j = 0$$

$$\dot{V} = 0$$



$$\tau \dot{y} = -y + \varepsilon(1-y) - f(y+1)$$

$$\tau \dot{\varepsilon} = k_1 y^2 + k_2 y^4 - (k_3 + k_4 f) \varepsilon = 0$$

$$\tau \dot{f} = k_5 (k_3 + k_4 f) \varepsilon - k_6 f$$

~~$$\tau \dot{y} = -y + (1-y)$$~~

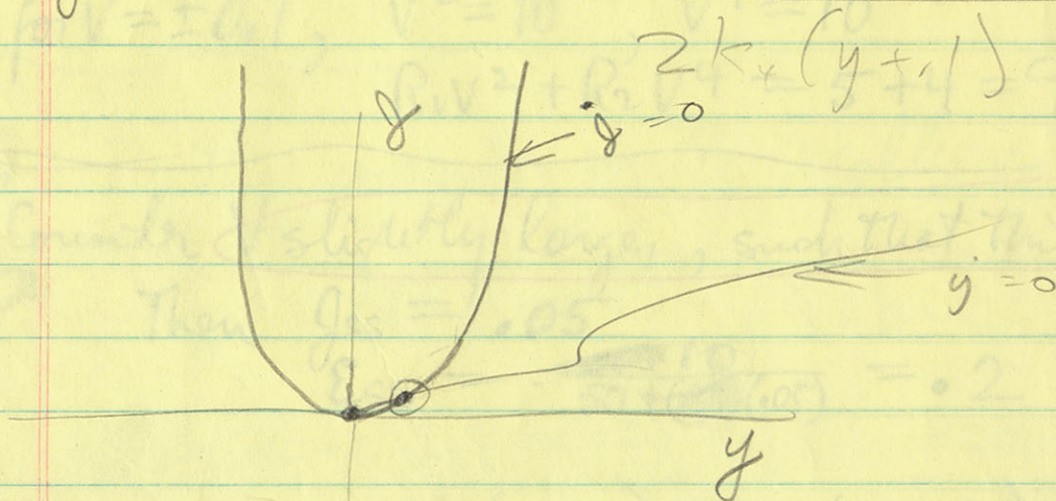
$$f = 0, \quad k_5 (k_1 y^2 + k_2 y^4) = k_6 f$$

$$y = 0, \quad -y + \frac{k_1 y^2 + k_2 y^4}{k_3 + k_4 f} f (y+1) = 0$$

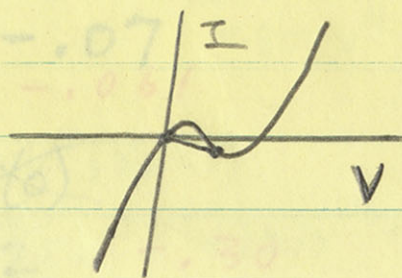
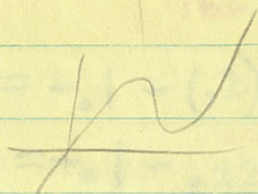
left this out

$$+ k_4 f (y+1) + k_4 y f + [k_3 y - k_1 y^2 - k_2 y^4 + k_3 (y+1)] f = 0$$

$$f = \frac{-(k_3 + k_4)y - k_3 \pm \sqrt{(k_3 + k_4)^2 y^2 - 4k_4(y+1)(k_3 y - k_1 y^2 - k_2 y^4)}}{2k_4(y+1)}$$



$$\tau \dot{f} < 0, f = 0: \dot{f} = k_5 k_3 \varepsilon$$



6/18/64

(2)

Take Series (5) or Series (7) and
examine for $V = 0.1$
 $V = -0.1$

Series (5) $R_1 = 500$,

$$R_2 = 4 \times 10^4$$

$$R_3 = 50$$

$$R_4 = 1$$

$$R_5 = 0.05$$

$$R_6 = 10$$

$$R_5/R_6 = 0.005 = \frac{1}{200}$$

$$I_{SS} = \frac{R_5}{R_6} (R_1 V^2 + R_2 V^4) = 0.005 (500 V^2 + 4 \times 10^4 V^4)$$

$$E_{SS} = \frac{R_1 V^2 + R_2 V^4}{R_3 + R_4 I_{SS}} = \frac{(500 V^2 + 4 \times 10^4 V^4)}{50 + I_{SS}}$$

for $V = \pm 0.1$, $V^2 = 10^{-2}$, $V^4 = 10^{-4}$
 $R_1 V^2 + R_2 V^4 = 5 + 4 = 9$

Opposite
become

Consider V slightly larger, such that this ≈ 10

Then $I_{SS} = 0.05$

$$E_{SS} = \frac{10}{50 + (0.05)} = 0.2 \quad \begin{matrix} 0.045 \\ 0.18 \end{matrix}$$

$$\psi_{SS} = V_{SS} - E_{SS}(1 - V_{SS}) + I_{SS}(V_{SS} + 1)$$

for $V_{SS} = 0.1$

$$= 0.1 - (0.2)(0.9) + 0.05(0.2)$$

$$= 0.1 - 0.18 + 0.01 = -0.07$$

.162 .009 -.061

for $V_{SS} = -0.1$

$$\psi_{SS} = -0.1 - (0.2)(1.01) + 0.05(0)$$

$$= -0.1 - 0.22 = -0.32 \quad \begin{matrix} .20 \\ -.30 \end{matrix}$$

Consider $V = \pm 0.01$, $V^2 = 10^{-4}$, $V^4 = 10^{-8}$
 $R_1 V^2 + R_2 V^4 = .05 + .0004 \approx .05$

Then $I_{SS} \approx 25 \times 10^{-5}$
 $E_{SS} = \frac{.05}{50} = 10^{-3}$

for $V = +.01$ $\psi_{SS} = +.01 - 10^{-3} (.99) + 25 \times 10^{-5} (.11)$
 $\approx +.009$

for $V = -.01$ $\psi_{SS} = -.01 - 10^{-3} (1.01) + 25 \times 10^{-5} (.09)$
 $\approx -.011$

zero is approx where $E_{SS} \approx V_{SS} \approx \frac{500V^2 + 4 \times 10^4 V^4}{50}$
approx for $V \times 10V^2$

Note: the three singular points really corresp. to cubic for $R_2 = 0$

~~consider first~~ let $R_1 = 0$, then

fastst.

~~$\psi_{SS} = \dots$~~
 $I_{SS} = \frac{R_5 R_2}{R_6} V^4 = 200 V^4$
 $E_{SS} = \frac{R_2 V^4}{R_3 + \frac{R_4 R_5}{R_2 R_6} V^4} = \frac{4 \times 10^4 V^4}{50 + 200 V^4}$
 $\approx 8 \times 10^2 V^4$ for small V
 $\approx 800 V^4$

for small V

stst. is $\psi = V - 800V^4(1-V) + 200V^4(V \pm .1)$

set $\psi = 0$, one root is $V = 0$ \therefore leave $10^3 V^4 - 780V^3 + 1 = 0$

for small V

$$V^4 - .78V^3 + 10^{-3} = 0$$

Consider next $R_2 = 0$

Try $R_1 = 10^4$

Then $I_{SS} = 50V^2$

$$I_{SS} = \frac{10^4 V^2}{50 + 50V^2} \approx 200V^2 \text{ for } V^2 \ll 1$$
$$= \frac{200V^2}{1+V^2}$$

~~for small~~ first st.

~~$\psi = V - \frac{10^4 V^2}{50}$~~

$$\psi = V - \left(\frac{200V^2}{1+V^2}\right)(1-V) - 50V^2(V+0.1)$$

for $\psi = 0$ get $0 = 1 - 200V\left(\frac{1-V}{1+V^2}\right) - 50V(V+0.1)$

$$200V(1-V) = (1+V^2)(1 - 50V(V+0.1))$$
$$-200V^2 + 200V = 1 + V^2 - 50V^2 - 5V - 50V^4 - 5V^3$$

But if $V^2 \ll 1$, set approx

$$-200V^2 + 200V = 1 - 50V^2 - 5V$$

$$-150V^2 + 205V - 1 = 0$$

approx $V^2 - 1.33V + .006 \approx 0$

$$(V - 1.33)(V - .0045) \approx 0$$

Comment.

May wish to run ~~with~~

One case with $R_1 = 10^4$, $R_2 = .1$

Another case with $R_1 = .1$, $R_2 = 4 \times 10^4$
 $\times 10^{-4}$

But returning to pages 2 & 3

There is a root between $V_{SS} = 0.1$
and $V_{SS} = 0.01$

Try $V_{SS} = .05$

Then $V^2 = 25 \times 10^{-4}$

$R_1 V^2 = 1.25$

$V^4 = 625 \times 10^{-8}$

$R_4 V^4 \approx 10^{-5}$

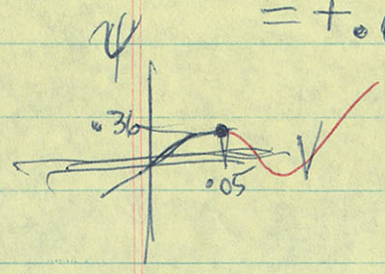
$\therefore I_{SS} \approx \frac{1.25}{200} = .00625$

$E_{SS} = \frac{1.25}{50 + E} = .025$

$V_{SS} = .05 - .025(.95) + .00625(.15)$

$= .0594 - .0237$

$= +.0357$



\therefore middle root lies between $V = .05$

and $V = .1$

8/14/64

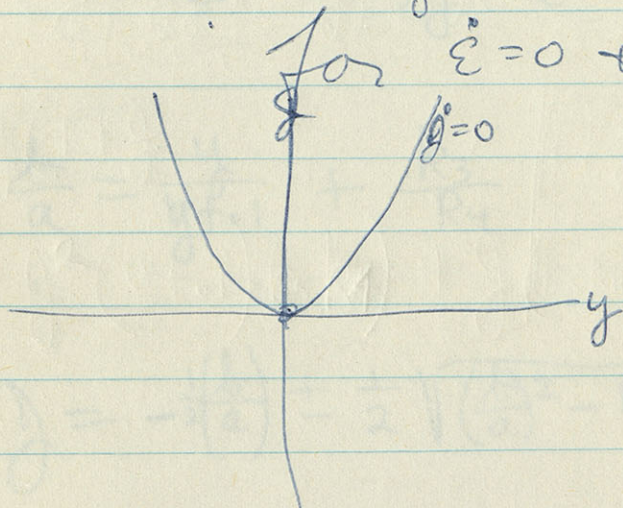
$$\dot{\epsilon} = 0 \text{ gives } \epsilon = \frac{k_1 y^2 + k_2 y^4}{k_3 + k_4 g}$$

$$\text{If } \dot{g} \text{ is also zero, then } \epsilon = \frac{k_6 g}{k_5 (k_3 + k_4 g)}$$

$$\text{also, then } g = \frac{k_5}{k_6} (k_3 + k_4 g) \epsilon = \frac{k_5}{k_6} (k_1 y^2 + k_2 y^4)$$

which gives a relation between g and y

for $\dot{\epsilon} = 0$ + $\dot{g} = 0$



However, for $\dot{g} \neq 0$ but $\dot{\epsilon} = 0$, then get

$$0 = -y + (1-y) \left(\frac{k_1 y^2 + k_2 y^4}{k_3 + k_4 g} \right) - g(y+1)$$

$$0 = -k_3 y - k_4 y g - \left(\frac{k_3}{y g + 1 g} \right) + (1-y) (k_1 y^2 + k_2 y^4) - k_4 g^2 (y+1)$$

$$\# k_4 (y+1) g^2 + (k_4 y + k_3 (y+1)) g + k_3 y + (1-y) (k_1 y^2 + k_2 y^4) = 0$$

2

$$J = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

where $a = k_4(y+0.1)$

~~b~~

$$b = k_4 y + k_3(y+0.1)$$

$$c = k_3 y - (1-y)(k_1 y^2 + k_2 y^4)$$

$$\frac{b}{a} = \frac{y}{y+0.1} + \frac{k_3}{k_4}$$

$$J = -\frac{1}{2} \left(\frac{b}{a} \right) \pm \frac{1}{2} \sqrt{\left(\frac{b}{a} \right)^2 - 4 \frac{c}{a}}$$

Note that for $y=0$, $c=0$

$$b = 0.1 k_3$$

$$a = 0.1 k_4$$

$$\text{and } J = \frac{-k_3 \pm k_3}{2k_4} = \begin{cases} 0 \\ \text{or} -\frac{k_3}{k_4} \end{cases}$$

but we exclude $-J$ values for physical reasons

for $g=0$

$$E = \frac{k_6 g}{k_5(k_3+k_4g)}$$

extra 2a
throwing $g=0$
in with $g=0$

Better $-y + \frac{k_6 g}{k_5(k_3+k_4g)}(1-y) - g(y+0.1) = 0$

~~$-y + k_6 g - k_6 g y$~~

$$(y + g y + 0.1 g)(k_5)(k_3+k_4g) = k_6 g(1-y)$$

~~$g(1+g)$~~

$$g^2(y+0.1)(k_5)(k_4) + g(k_5 k_4 y + k_5 k_3 (y+0.1)) - k_6 g(1-y) + k_3 k_5 y = 0$$

quadratic with

$$a = k_4 k_5 (y+0.1)$$

$$b = (k_6 + k_5(k_3+k_4))y + \frac{k_3 k_5 - k_6}{10}$$

$$c = k_3 k_5 y$$

$$g = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

~~$J = -k_4 k_5 y$~~

Before going away
≈ July 1, 1964

Hypothesis

Suppose there are not really two groups of branch lengths, but merely a wide range of variation.

Then the shortest lengths are least likely to be cut & are fairly likely to be shorter than the truncated lengths of the long cut branches. This might be the basis for group II.

For those neurons with less variation in length (perhaps group III, also cases 3 & 4 of Monticelli neurons) the truncated lengths tend to be shorter than bifurcating lengths.

Plan cases 5, 6 & 7 to check this idea.

4/21/64

$$\frac{2r}{h}$$

suppose $h = 200$

suppose $r = 150$

$$\text{Then } \frac{2r}{h} = \frac{3}{2}$$

ie. $\frac{2}{3}$ not cut
 $\frac{1}{3}$ cut

30 of 86 agree pretty well with this.

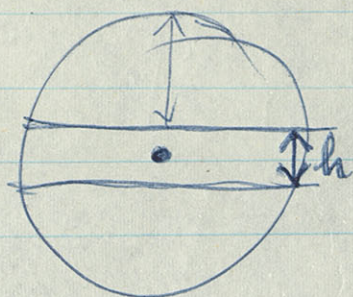
$$\text{If } r = 500, \text{ so } \frac{2r}{h} = \frac{10}{2} = 5$$

\therefore chance of survival = $\frac{1}{5}$

$$r = 800, \text{ so } \frac{2r}{h} = \frac{16}{2} = 8$$

chance of survival = $\frac{1}{8}$
provided tree is straight.

4/20/04



$$\text{volume of sphere} = \frac{4}{3} \pi r^3$$

$$\text{volume of slab} \approx \pi r^2 h$$

$$\text{ratio} \approx \frac{h}{\frac{4}{3} r} \approx \frac{2}{\frac{4}{3} \times 10} = \frac{3}{20} = 0.15$$

$$\frac{3h}{4r} = \left(\frac{3}{4}\right) \left(\frac{h}{r}\right)$$

$$\text{hemisphere vol} = \frac{2}{3} \pi r^3$$

$$\text{let } z = r - \frac{h}{2}$$

$$\text{spherical seg less centered slab} = \frac{1}{3} \pi z^2 (3r - z)$$

$$\text{Suppose } z = 0.9r, \text{ get } \frac{1}{3} \pi (0.81r^2) (2.01r)$$

$$= \frac{1}{3} \pi r^3 (1.7)$$

$$\therefore \frac{\text{seg}}{\text{hemisphere}} = \frac{1.7}{2}$$

$$\therefore \frac{\text{slab}}{\text{sphere}} = \frac{0.3}{2} = 0.15$$

Except for V close to 1.

in particular, for V from .5 to .8

C_{max} occurs almost simultaneously with ε_{max} .

If make this simplifying assumption

Then $\varepsilon (R_3 + R_4 j) = R_1 V^2 + R_2 V^4$

$$\varepsilon \frac{dj}{dt} = (R_5 (R_1 V^2 + R_2 V^4) - R_6 j)$$

~~and $\frac{d\varepsilon}{dt} = 0 \approx \frac{dV}{dt} (V + 0.1)$~~

$$\varepsilon \frac{dj}{dt} = \text{const} - R_6 j$$

given an estimate of TK^*
can get an estimate of j .



Then $\varepsilon \frac{d\varepsilon}{dt} = \text{const} - (R_3 + R_4 j) \varepsilon$

get est. of ε
& plug into equation for C .

$$C = V - \varepsilon(1-V) + g(V+0.1)$$

When $\frac{dC}{dt} = 0$

with clamped ~~the~~ ^{potential}

$$\frac{dC}{dt} = 0 - \frac{d\varepsilon}{dt}(1-V) + \frac{dg}{dt}(V+0.1)$$

$$\frac{d\varepsilon}{dt}(1-V) = \frac{dg}{dt}(V+0.1)$$

$$\varepsilon \frac{d\varepsilon}{dt} = (R_1 v^2 + R_2 v^4) - (R_3 + R_4 g) \varepsilon$$

$$\varepsilon \frac{dg}{dt} = R_5 (R_3 + R_4 g) \varepsilon - R_6 g$$

$$(1-V) \left\{ R_1 v^2 + R_2 v^4 - (R_3 + R_4 g) \varepsilon \right\} = (V+0.1) \left\{ \right.$$

$$\left. \left\{ R_5 (R_3 + R_4 g) \varepsilon - R_6 g \right\} \right\}$$

9/10/64

in 669 active at soma $\left| \frac{+}{-} \right| = \left| \frac{1.13}{1.59} \right| = 0.71$

at glom. $\left| \frac{-}{+} \right| = \left| \frac{.285}{.385} \right| = 0.74$

peak to peak $\frac{\text{soma}}{\text{glom}} = \frac{2.72}{.67} = 4.06$

results from Shindorf

666
penne

at soma $\left| \frac{+}{-} \right| = \left| \frac{.451}{1.43} \right| = 0.315$

at glom $\left| \frac{-}{+} \right| = \left| \frac{.115}{.345} \right| = 0.334$

peak to peak $\frac{\text{soma}}{\text{glom}} = \frac{1.88}{.46} = 4.09$

Peak No. 9.
 of data being used
 for figures

depths

03	18mm	0.400	0.308
041	23	0.512	0.393
05	29.5	0.656	0.504
056	33.5	0.745	0.570
06	39.5	0.880	0.675
064	45.0	1.00	0.770
068	58.5	1.00	1.00
074	59.		
091	50.5		

if this were
 neutral level

act.

64794.8827

Neg peak amplitudes
Rel

Sp. No.	Amplitude	Rel
4	-0.3415	1.000
5	-0.3329	0.974
6	-0.2781	0.813
7	-0.1979	0.580
8	-0.1136	0.333
9	-0.0465	0.136
10	-0.0279 flat	0.082
11	-0.0424 reverse	0.124
12	-0.0514	0.150
13	-0.0568	0.166
14	-0.0595	0.174

about half

35
10

3.5

64791.0669 active

			+
Cpts	4	-1.5899	1.000
	5	-1.5726	.990
	6	-1.4606	.920
	7	-1.1778	.740
	8	-.5869	.370
	9	-.2846	.180

64791.0666 positive

+

Opto 4	-1.4298	1.0000
5	-.7843	.550
6	-.3729	.260
7	-.1500	.105
8	-.0968	.068
9	-.1151	.080

Partial Differential Equations of Second Order

Laplace Equation (elliptic type)

(harmonic
analytic)

$$u_{xx} + u_{yy} + u_{zz} = 0$$

Wave Equation (hyperbolic type)

$$u_{xx} + u_{yy} - u_{zz} = 0$$

Heat Equation (parabolic type)

$$u_z = u_{xx} + u_{yy}$$

Mixed Type $L(u) = a u_{xx} + 2b u_{xy} + c u_{yy}$

elliptic if $ac - b^2 > 0$

hyperbolic $ac - b^2 < 0$

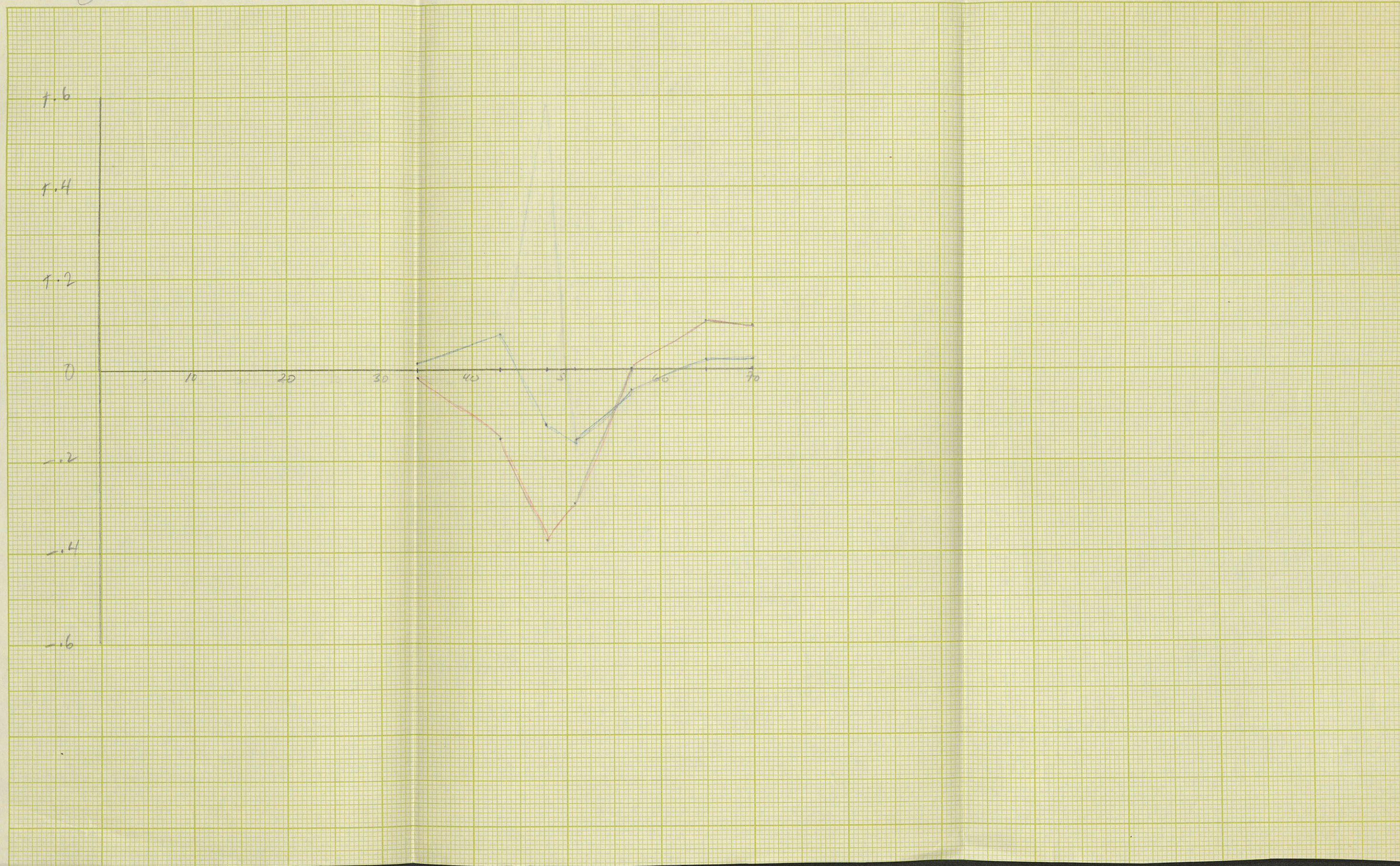
parabolic $ac - b^2 = 0$

Calc. mod. of 64791.0666 passive

9/17/64

Blue is new pot. divider case (with prim. diluted by sec)
Red is old pot. divider case

(6)



64791.0666

9/17/64

At compartment 6

Begin with unstimulated values

without potential divider

KT
34

43

51

57

70

48

65

Value in 6(A)	-0.064	-0.492	-0.355	0.109	0.183	-0.593	0.212
7(B)	-0.026	-0.209	-0.210	0.034	0.094	-0.306	0.106
8(C)	-0.008	-0.062	-0.077	0.006	0.032	-0.103	0.035
4(S)	-0.256	-1.748	-0.327	0.503	0.428	-1.141	0.518
0.4 × A	-0.226	-0.196	-0.142	0.044	0.073	-0.237	0.085
0.3 × B	-0.008	-0.063	-0.063	0.010	0.028	-0.092	0.032
0.2 × C	-0.002	-0.012	-0.015	0.001	0.006	-0.021	0.007
NU	-0.036	-0.271	-0.220	0.055	0.107	-0.350	0.124

for potential divider shift.

$$P = 0.2 \times S \quad -0.051 \quad -0.349 \quad -0.065 \quad 0.101 \quad 0.085 \quad -0.228 \quad 0.103$$

$$NU - P \quad +0.015 \quad 0.078 \quad -0.155 \quad -0.046 \quad 0.022 \quad -0.122 \quad 0.021$$

Compare with old stimulated values (in 6)

$$-0.016 \quad -0.151 \quad -0.294 \quad 0.006 \quad 0.096 \quad -0.373 \quad 0.107$$